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EVOKED CORTICAL POTENTIALS AND

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Prepared by: J. L. Andreassi
Principal Investigator
J. A. Gallichio
and
N. E. Young

For: The Office of Naval Research
Contract N00014-77-C-0114

Annual Report
31 December, 1977

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See 1473

Fifth Annual Report

ABSTRACT

This is the fifth annual report to originate from the Psychophysiology Laboratory of the Psychology Department at Baruch College. The research completed over the last 12 months has included a number of studies concerned with evoked cortical potential correlates of stimulus processing in humans. The present report details the results of five separate experiments. Experiment I examines the visual evoked potential (VEP) to a larger stimulus when it is perceptually masked by a second stimulus, and again when it is disinhibited. The disinhibition occurs when the target is clearly perceived because of the action of a third stimulus on the second. There was a significant trend toward a larger amplitude VEP to the target when it was disinhibited. More research work is needed in this area since so little information is available on the brain response to disinhibited or recovered stimuli.

In Experiment II, the effects of contiguity of target (initial) and mask (later) visual stimuli on backward masking and the VEP was examined. However, the area of the mask was varied so that it was either 68% or 97% of the target's area. Significant VEP amplitude decreases occurred when the target was followed closely in time by either of the masks.

Experiment III tested the effects of differing numbers of corner masks on perception of, and VEP to, the target stimuli. Two-corner masks (upper left and lower right) led to partial masking, but no significant VEP amplitude decrease. Four-corner masks produced more complete masking in all subjects, and a corresponding significant decrease in VEP magnitude. The two-corner mask was only 29% of the target area, while the four-corner mask occupied 57% of the area covered by target stimuli.

In Experiment IV we asked whether corner masking stimuli would be more effective than non-corner masks with respect to effects on perception and the VEP. Both corner and non-corner masks occupied less area than the target stimuli (57%). The two mask types were equally effective in producing backward

masking and attenuation of the N2-P2 component of the VEP.

The fifth experiment examined the effects of a "randomly" generated noise pattern on a target. The target was a letter T and the mask overlapped and crisscrossed the T at many points along its contour. The random visual pattern proved to be a very effective mask perceptually and also led to sharp decreases in VEP amplitude. -A delay was found for P2 latency at the C_z (Central) location as compared to the O_z (Occipital) area. This was related to the fact that O_z is the primary projection area for visual stimuli. The general finding of VEP attenuation with backward masking was interpreted in terms of excitatory-inhibitory interactions at the visual cortex which occur when later presented stimuli bound, or spatially overlap, earlier presented target stimuli.

Experiment I: The Visual Evoked Potential to a Disinhibited Stimulus

The disinhibition effect is a variation of backward visual masking first reported by Robinson (1966). The usual backward masking paradigm involves the presentation of a stimulus (target) followed after a short delay by another stimulus (mask) which interferes with the perception of the target. In Robinson's experiment a circular flash of light (.23 deg diameter) was presented for 20 msec, followed after 25 msec by a masking stimulus, a flash of light 46 deg in diameter. The target stimulus was effectively masked. However, when a third, larger (.92 deg) light flash was presented 20 msec after the second flash, the target was detected on 80% of the trials, but the second flash was not perceived at all. What apparently happened was that the second mask "disinhibited" the target from the effects of the first mask, thus allowing the it to be perceived. The luminance and duration of the three flashes were constant at 5 mL and 20 msec, respectively.

Dember and Purcell (1967) obtained similar results. Detection of a target stimulus was greater when masks 1 and 2 followed the target as compared to when the target and mask 1 only were presented. In their view the target was never completely eliminated from the visual system by mask 1, but remained in short-term memory storage. When mask 2 was presented it suppressed mask 1 and allowed the target to enter

perceptual awareness. The disinhibition effect would appear to be a reliable phenomenon in view of the number of other investigations in which its occurrence has been reported (viz., Mayzner, 1970; Mayzner, Tresselt & Helfer, 1967; Robinson, 1968; Schiller & Greenfield, 1969; Tresselt, Mayzner, Schoenberg & Waxman, 1970). However, while there have been studies concerning the visual evoked potential (VEP) and backward masking (e.g., Andreassi, Mayzner, Beyda & Davodovics, 1971; Andreassi, Stern & Okamura, 1974; Andreassi, DeSimone & Mellers, 1976a; Donchin & Lindsley, 1965; Donchin, Wicke & Lindsley, 1963; Schiller & Chorover, 1966; Vaughan & Silverstein, 1968) we are aware of only one study in which VEPs to disinhibited stimuli have been studied (Schwartz, Whittier & Schweitzer, 1977, personal communication). Since nervous system mechanisms have often been postulated as playing a role in backward visual masking it would seem appropriate to use some measure of CNS response to stimuli involved in both the backward masking and the disinhibition paradigms.

In the experiment conducted by Schwartz et al[1]. Target stimuli consisted of four block letters. When Targets were

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[1] Target stimuli were presented for 7 msec and were 7 ftL in intensity. Mask 1 consisted of black bars (20 msec duration) which appeared 10 msec after the target. Mask 1 was 2.5 ftL and subtended the same visual angle as the target and background (40'). Mask 2 was a blank light flash (15 ftL) which spatially overlapped earlier stimuli (80'), and was presented 10 msec after Mask 1 for a duration of 50 msec.

followed by Mask 1, subjects had difficulty in discriminating them. When Mask 2 was introduced, detection performance improved greatly (80% to 100% correct). The VEPs to Targets, however, did not differ for the condition in which Targets were not identified (one Mask) as compared to when discrimination was very good (two Masks). Or, to phrase it another way, the VEP to the Target was similar regardless of whether it was inhibited or disinhibited. Thus, the perceptual performance was dissociated form the VEPs.

In our present study we endeavored to study the VEP to a disinhibited stimulus with the following specifications: (1) that all stimuli (Target, Mask 1 and Mask 2) be approximately the same intensity, (2) that all stimuli be patterned, and (3) that all subjects be screened to ensure that they experienced masking of the Target when only one Mask was presented, and disinhibition of the Target when two Masks were presented. Based upon the results of previous studies (e.g., Vaughan & Silverstein, 1968; Andreassi et al., 1976a) we hypothesize that: (1) the VEP to the Target + Mask will be of lower amplitude than to the Target alone, (2) the VEP to the disinhibited Target will be larger in amplitude than when it is masked, and (3) the VEP to the Target alone and the disinhibited Target will be the same.

METHOD

Subjects: The subjects were five males and four females associated with the City University of New York. None had visual system defects other than myopia (corrected to at least 20/25).

Apparatus and Procedure: The apparatus used to obtain the VEP included a Beckman Dynograph, a computer of average transients (CAT/1000), an X-Y plotter and a PDP-8/E computer with its associated Teletype. Stimuli were displayed on a VR-14 CRT (Digital Equipment Corp.) which was mounted at the subject's eye level. The subject viewed the displays from inside an electrically shielded and sound-attenuated IAC Chamber. The CRT was under program control of the PDP-8/E computer. A small fixation point, 3mm in diameter, was used to maintain the subject's line of vision towards the center of the CRT. The fixation point was a dim (0.001 mL) red neon light source located 6mm above the center of all stimulus arrays presented on the CRT. The computer was programmed so that the total luminous energy appearing on the CRT screen was approximately equal under all stimulus conditions. In no case were Masks more intense than Target stimuli.

The EEG of each subject was recorded from O_z ("Ten-Twenty" System, Jasper, 1958) with Grass silver cup electrodes referenced to a silver clip electrode on the subject's left ear lobe. Electrode resistance was maintained at 5,000 Ohms or less. The subject was grounded by another electrode attached to the right ear lobe leading to "patient ground" of the Dynograph. The filtered (bandpass at 0.5 to 32.0 Hz) and

amplified EEG signal was sampled by the CAT every time a stimulus was presented. One hundred EEG samples, each of 500 msec duration after the stimulus, were taken for each averaged potential. On-line monitoring of the EEG was accomplished with a Tektronix 502A oscilloscope to monitor possible artifacts in the EEG record. The vertical electro-oculogram (EOG) was recorded and averaged on a separate channel of the CAT to detect possible VEP distortions due to eye movement or blinking. The averaged EOG trace was examined after every trial.

The basis for construction of experimental stimuli was a 5X7 matrix array consisting of 35 yellow-green points of light, which could be presented on the CRT under program control of the PDP computer. Our target and masking stimuli were constructed as follows:

Condition A- Two target Y's, formed by illuminating the appropriate elements of the grid. They appeared on the screen for 20 msec.

Condition B- Two target Y's, followed by two "complements" (mask 1) of the letter Y's, i.e., the points of light remaining after the removal of those used to form the Y's. (See Figure 1.) These complements were presented 35 msec after the 2 Y's disappeared from the screen.* They were also on the screen

*Disappearance was virtually immediate (50 μ sec) with the brief persistence P24 phosphor specially installed in the VR-14.

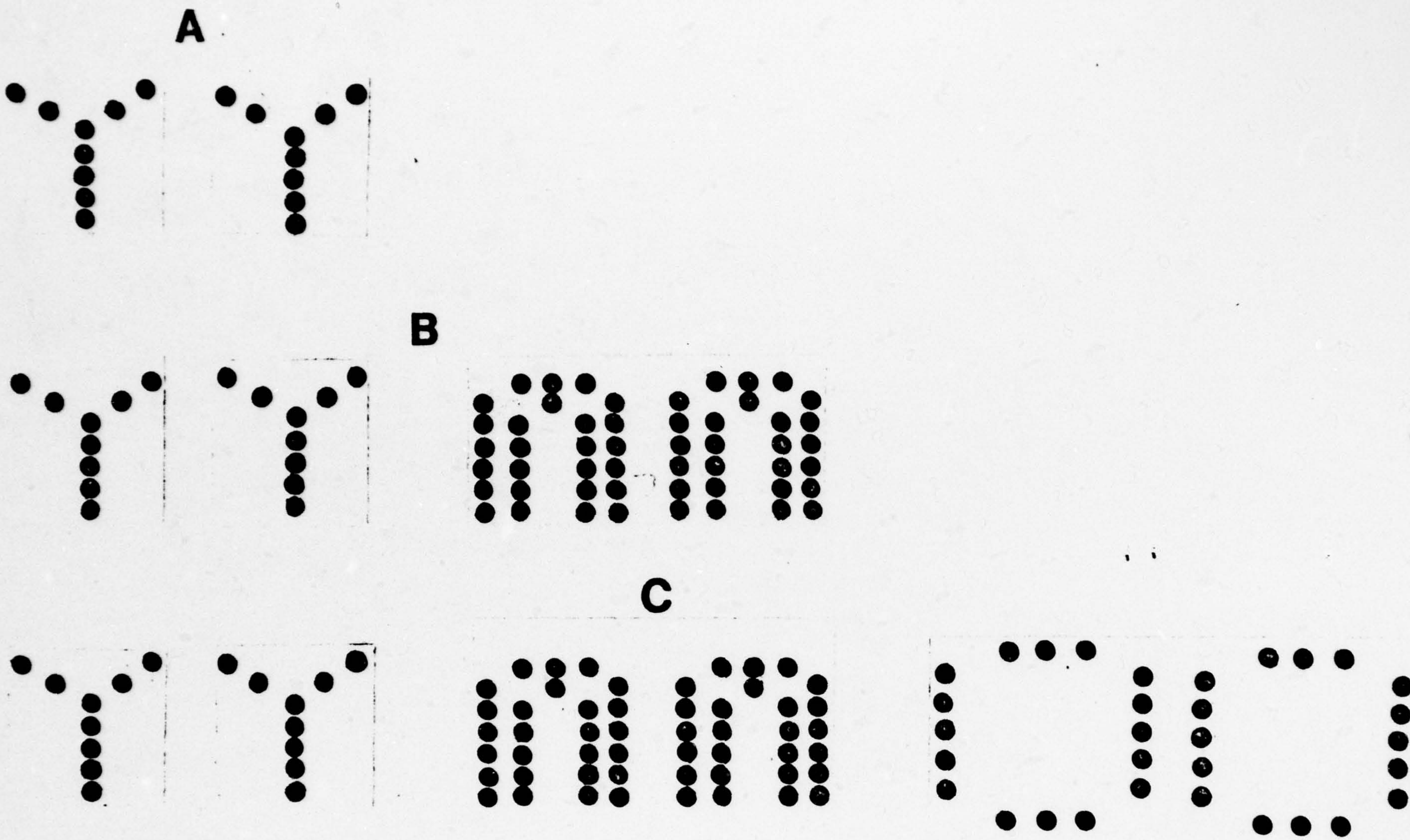

Figure 1 - Schematic of Conditions A, B and C. Condition A consisted of a pair of target Y's, Condition B consisted of the target Y's followed by their complements occurring at the same spatial location and Condition C consisted of the Y's followed by the complements which were followed by a pair of slightly larger circles at the same spatial location.

for 20 msec.

Condition C- Two Y's were followed by two complements, as in Condition B, but two letter O's (mask 2) followed the complements after 35 msec, and remained on the screen for 20 msec. Mask 2 was larger than mask 1 (see Figure 1).

Thus, all of the stimuli were on the screen for 20 msec, and there was an ISI of 35 msec, i.e., 35 msec intervened between the disappearance of one stimulus and the appearance of the next upon the screen. In every instance there was always 1000 msec between each stimulus set. For example, two Y's and two complements were presented in rapid succession, followed by a pause of 1000 msec, and the next set of two Y's and two complements appeared. The luminance of the Y's was 1.50 mL each (measured at a distance of 2.54 cm with a Tektronix J16 Digital Photometer). The two complements (mask 1) also measured 1.50 mL each, while the two O's (mask 2) produced an intensity of 1.30 mL each. The target Y's and the complements were 3.5 cm across, and at a distance of 137 cm produced a visual angle of 1 deg 30' of arc. The O's were slightly larger, measuring 3.7 cm in width (a visual angle of 1 deg 35' of arc). Each potential subject was screened to ensure that masking was obtained under Condition B and disinhibition with Condition C. The procedure involved devoting a session to obtaining reports based on 100 presentations of each condition. Subjects

were asked to sketch what they saw on the screen after each 100 presentations. Their drawings indicated masking in Condition B if they produced only the complements of the Ys and disinhibition was shown for Conditon C if they drew and described two Ys followed by two Os with no indication at all that the complements had been perceived. Condition C produced consistent disinhibition reports, since subjects reliably sketched a "Y-O" and "Y-O" in all screening trials.

The three conditions were completely counterbalanced across the 9 subjects over a period of 3 days. Each subject was presented with each condition six times during the course of three experimental sessions, for a total of 18 VEP traces from O_z, with each trace based on 100 presentations.

The data analysis was accomplished by computing the mean amplitudes (uV) and latencies (msec), for each subject, for the obtained VEPs. The N1 component was considered to be the first negative dip in the trace, from the baseline, which occurred 50 msec after the stimulus. The baseline was determined by the horizontal portion of the X-Y plot. The N1-P1 component was measured as the vertical distance from the trough of the N1 component to the first positive peak. The N2-P2 component was measured as the vertical distance between the second depression (trough) and the second peak. Latencies (or time after stimulus presentation) were measured to the midpoints of each positive peak. If the "peak" was flat and appeared more as a plateau, the midpoint of the plateau was taken as the latency measurement.

RESULTS

The perceptual reports, and diagrams produced after each conditions indicated that all subjects perceived the two target stimuli at all times (Condition A). In addition, complete perceptual masking was obtained under Condition B, while the target stimuli were consistently disinhibited in Condition C. Mean amplitude and latency data were computed for all subjects and conditions are presented in Tables 1 and 2. The data from Tables 1 and 2 are plotted as Figures 2 and 3.

Table 1

Mean Amplitude (Microvolts) of VEP Components Under Conditions A, B and C (N = 9)

VEP Component	Conditions A	B	C
N1 - P1	4.00	3.78	4.87
N2 - P2	6.60	5.71	6.63

The amplitude data in Table 1 indicate some differences between VEP components under the three conditions and this is graphically illustrated in Figure 2. The latency data indicated only small differences between conditions (see Figure 3).

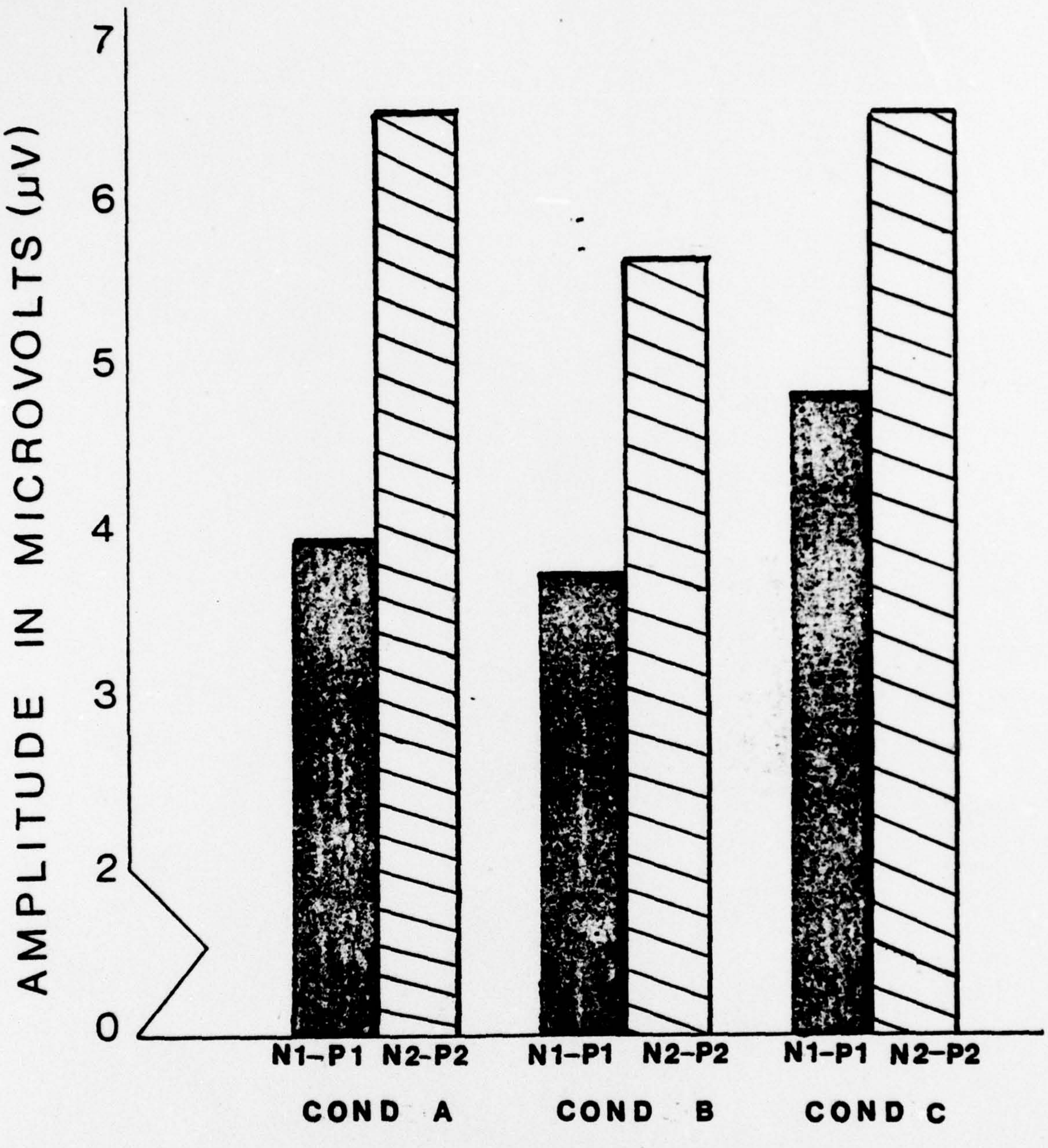

Figure 2- Mean amplitude of major VEP components (6 Ss) under conditions A,B, and C.

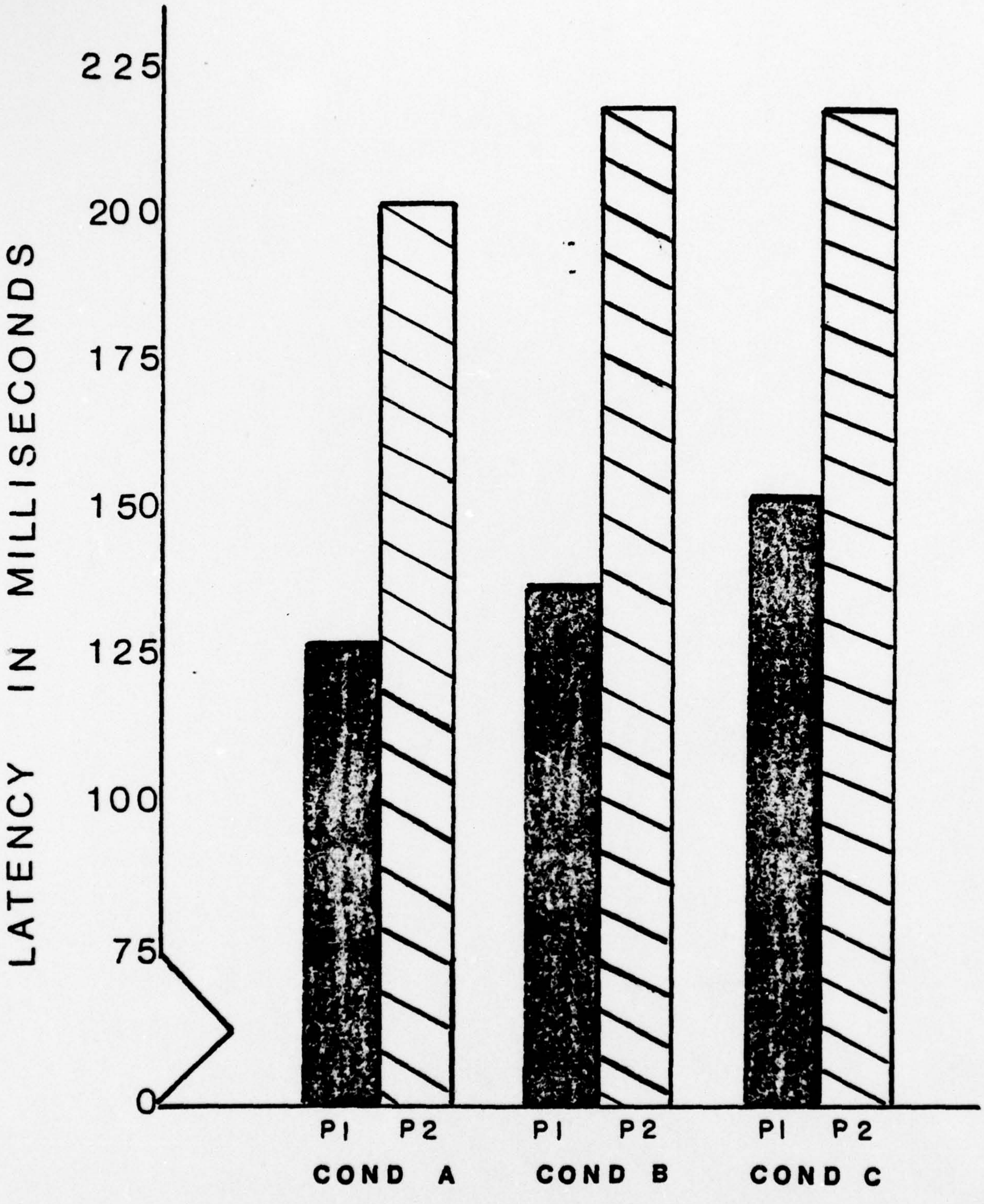

Figure 3 Mean latency of major VEP components (6 Ss) under conditions A,B, and C.

Table 2

Mean Latency (Milliseconds) of VEP
Components Under Conditions A, B and C
(N = 9

VEP Component	Conditions A	B	C
P1	128	136	155
P2	215	220	220

The data for one VEP component* (N2 - P2) were subjected to analysis by t-tests for correlated data (two-tailed criterion, 8 df). The results of the t-tests for the N2-P2 component: A vs.B, ($t = 4.13$, $p < .01$); A vs.C, ($t = .819$, $p > .05$); B vs. C. ($t = 2.87$, $p < .05$). The latency comparisons yielded no significant findings ($p > .05$ for all). The superimposed traces for one subject, M. L., under each condition, are shown in Figure 4. The mean N2-P2 amplitude for this subject was 5.25 μV for Condition A, 4.00 μV under Condition B, and 6.50 μV under Condition C. Subjective descriptions and drawings indicated similar perceptions for all persons. For example, under Condition A, it was typically reported that "two bright yellow Ys" were seen (2 Ys were actually presented). Under Condition B only the complements for Y were seen as, for example, "horseshoes with dark Ys inside" (i.e., when 2 Ys were followed by two complements).

*The N2-P2 component has proved to be the most consistent and reliable of the VEP measures under the conditions described in this report.

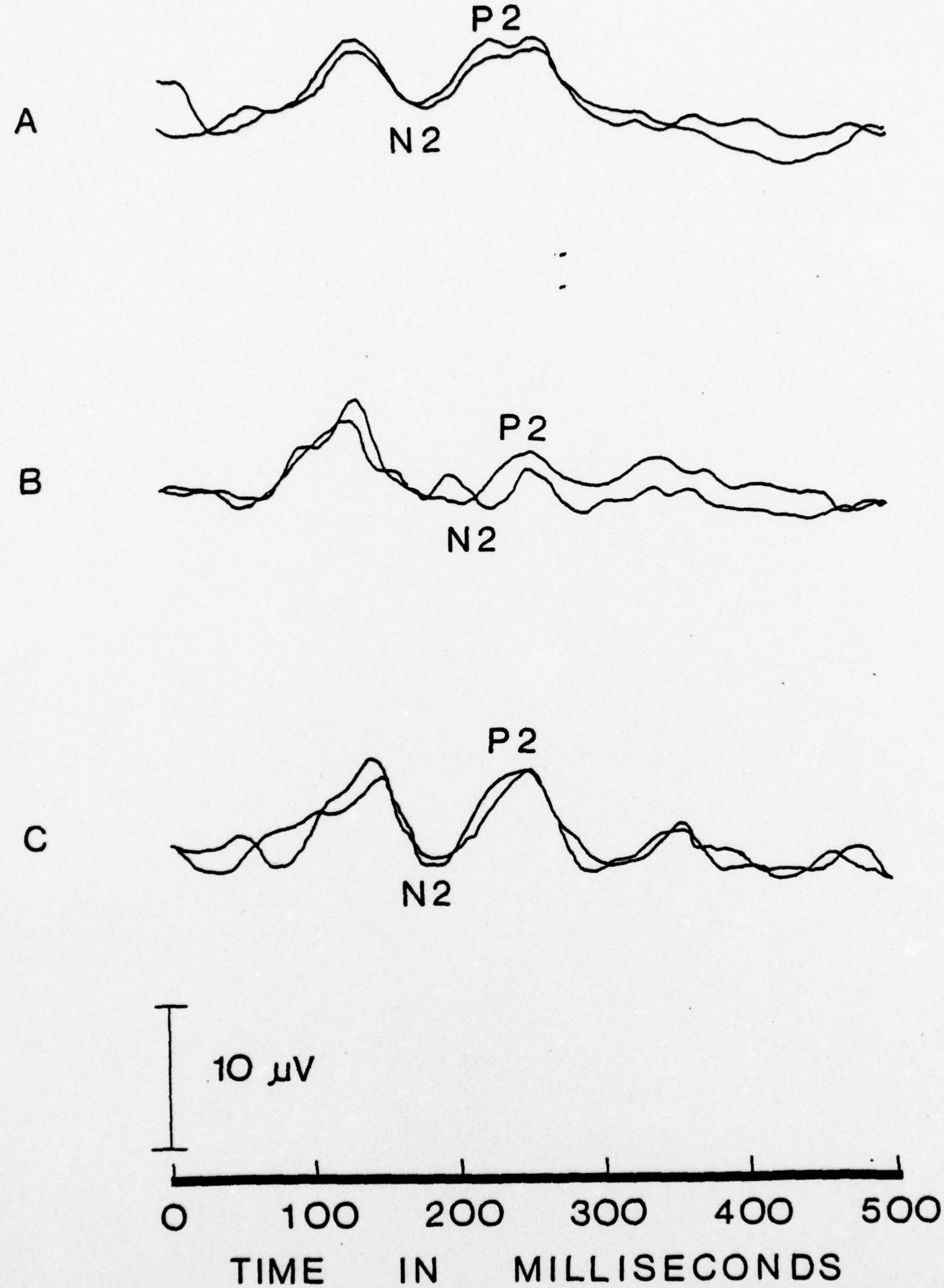

Figure 4- Superimposed VEP traces for one subject(M.L.). Each trace is based on 100 presentations (negativity is downward).

The report of a "dark Y" would indicate that the actual targets (yellow Ys) were not seen. A typical report for Condition C (disinhibition) was "2 yellow Ys followed quickly by 2 Os." This indicated that the target Ys and the second mask only were seen. Thus, through the subjective drawings and verbal reports we believe we have established a paradigm in which inhibition of a target by a mask occurred. In addition, the subsequent recovery of the target was obtained when the first mask was itself inhibited by a second mask.

DISCUSSION

The results of the present study with regard to the hypotheses proposed show that all three were supported by the statistical tests. First, the hypothesis that the VEP response amplitude to the target would be decreased in amplitude through the inhibitory effects of mask 1 was borne out. It is clear that the VEPs obtained in Condition B are to the target because the latency and waveform are so similar to those produced when the target was presented alone. This amplitude result is similar to those obtained by Vaughan and Silverstein (1968) and Andreassi et al. (1976a) in which decreased VEP amplitude to target stimuli were obtained in situations where the target was suppressed or perceptually masked.

Andreassi et al. (1976b) found evidence for a functional relationship between the amount of target-mask contour inter-

action, i.e., the number of sides on which a target was bounded, and the degree of VEP attenuation (more specifically, increasing amounts of contour interaction resulted in progressive VEP attenuation). The contour interaction hypothesis may help explain the present results since the target letter Y was completely bounded by the complement (see Figure 1). It should also be noted that the present results are not like those of Donchin et al. (1963), Donchin and Lindsley (1965) and Fehmi et al. (1969) in which VEPs were found to occur in response to the mask rather than the target. However, in these studies the mask was of much greater intensity than the target (from 100 to 10,000 times) while in the present study masks were equal to, or less intense than, the target stimuli luminance. Also, the SOA* which produced masking in the Fehmi et al. study was 20 msec compared with a 55 msec SOA in the present study. These differences may possibly account for the different VEP effects obtained.

The second hypothesis, that the response to the disinhibited target would be greater than that obtained when the target was masked, was also supported. This result is not like the results of Schwartz et al. (1977) (personal communication) who found that VEPs to the disinhibited targets were

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*Simulus onset asyncrony, or time between onset of the target and onset of the mask.

comparable to those obtained when the targets were masked. Some possible reasons for the difference between these studies are: (1) the type of masks used (i.e., black bars and a blank light flash used in the Schwartz et al. study) compared with complements and letter "O" used in the present study; (2) the differences in intensity and SOAs used in these two studies; and (3) the fact that mask 2 spatially overlapped the earlier stimuli in the Schwartz study and the masks used did not overlap earlier stimuli in the present study.

Schiller and Greenfield (1969) have suggested that the disinhibition effect may have as its locus the receptive field in groups of retinal ganglia or lateral geniculate nucleus cells. They suggest further that the effects of mask 2 may be to reduce the number of discharges in neurons which have as their receptive fields the borders of mask 1. As a result, the response to the target becomes more pronounced. The result of the present experiment would seem to indicate that we may be observing a process at a cortex level similar to the one suggested by Schiller and Greenfield. That is to say, a succession of visual stimuli produce excitation, inhibition, and disinhibition which are reflected in the VEP recorded from over the occipital cortex.

In summary, it is suggested that when a target is presented alone it produces neuronal responses at the visual cortex (reflected in the VEPO and it is clearly perceived.

When it is spatially bounded by a later-appearing mask 1, it is not perceived and the VEP to the target is decreased in amplitude. It is hypothesized that neurons stimulated by mask 1 interfere with those in adjacent areas, which had already started to respond to the target. If mask 1, in turn, is spatially bounded on all sides by an even later-appearing mask 2, the activity of neurons responding to mask 1 is reduced by those in adjacent areas now firing in response to mask 2. Mask 1 is thereby prevented from inhibiting the target and is itself masked. The final result is a clear perception of the target and mask 2, and a restoration of target-produced VEPs to an amplitude level similar to that when it was presented alone.

Experiment II: Backward Masking Produced by Contour Interaction and its Effects on the VEP

A number of studies have obtained complete VEP suppression or amplitude reduction with backward masking paradigms in which the first stimulus (Target) was perceptually blanked by a second stimulus (Mask).[1] These studies include those of Donchin, Wicke and Lindsley (1963); Donchin and Lindsley (1965); and Fehmi, Adkins and Lindsley (1969) in which a very intense blanking flash complete suppressed the VEP to a less intense Target flash. Metacontrast paradigms were used by Schiller and Chorover (1966) and Vaughan and Silverstein (1968). While Schiller and Chorover did not find VEP changes under conditions of metacontrast suppression (where brightness changes but intensity does not), Vaughan and Silverstein found VEP amplitude reductions with metacontrast for foveal, but not parafoveal stimulation. Vaughan and Silverstein believe that the earlier failure to obtain VEP reductions by Schiller and Chorover was due to the parafoveal stimulation conditions used.

Andreassi et al. (1976a, 1976b) obtained evidence for VEP reduction when Targets were bounded on two sides by later presented stimuli, and Target stimuli were perceptually suppressed.

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[1]The term Target refers to stimuli which the subject is asked to identify. In backward masking paradigms it is always presented first. The Mask is presented after the target and, depending on timing, location, duration, and intensity, it may affect perception of the Target in some manner. Stimulus onset asycnrony (SOA) indicates the time between onset of the Target and onset of the Mask. The inter-stimulus interval (ISI) refers to the time between offset of a Target and onset of a Mask.

They also reported that when mask stimuli differed in configuration from targets, the targets were not perceptually suppressed and VEP was not attenuated. In the Andreassi et al. (1976b) study effective masking stimuli bounded the target on two, three and four sides. Since both targets and masks were 5 X 7 grid arrays, the effective masks were either two, three or four times the area of targets. The question we will examine in the present experiment concerns the perceptual and VEP effects of masks which are either less, or approximately, equal in area, as compared to targets. More specifically, in one masking condition, the area of the mask was 68% in relation to the target, and in the second it was 97% the area of the target.

METHOD

Subjects: The subjects were five males and one female. All were associated with Baruch College of the City University of New York. None had visual defects other than myopia (corrected to at least 20/30).

Apparatus and Equipment: Subjects were seated in an electrically shielded sound attenuated room (IAC Chamber). All experimental sessions were conducted with the lights dimmed. The VEP was was obtained from O_z and the procedure for obtaining it was identical to that used in Experiment I, except for the specific stimuli used. The stimuli were displayed on a Digital Equipment Corp. VR-14 CRT which was mounted at the subject's eye level outside the Chamber at a distance of 49 inches (124.5 cm). The VR-14 CRT was controlled by the DPD-8/E digital computer which was programmed to deliver stimuli at specific times and locations upon the CRT.

There were three conditions, each comprised of grids and lines:

Condition A- One grid on the screen for 30 msec (ON time of 20 msec)

Condition B- One grid for 20 msec, followed by four surrounding lines 60 msec later (ON time 20 msec, OFF time 60 msec)

Condition C- One grid for 20 msec, followed by six surrounding lines 60 msec later (ON time 20 msec, OFF time 60 msec)

In every instance, there was always 1000 msec between each set of stimuli. For example, a single grid with four lines was presented in rapid succession, followed by a pause of 1000 msec before the next set of stimuli. The spatial arrangement in which the stimuli appeared upon the screen is represented in Figure 1. The unfilled dots indicate target stimuli while solid dots represent masking stimuli. All dots were identical in diameter.

The single 1.0 cm square grid produced a visual angle of 28 min of arc in Condition A. In Condition B, the target plus mask produced a visual angle of 42 min of arc. In Condition C, the target plus mask produced a visual angle of 46 min of arc. Therefore, the stimuli in all cases were presented foveally, since foveal extent is 2-2.5 deg of visual angle (Ruch, 1965).

The intensity of a single grid was 2.2 millilamberts (mL) as measured from a distance of 2.54 cm (one inche) with a Tektronix Digital Photometer. The masking stimuli (lines) had an intensity in Condition B of 1.6 mL and 1.9 mL in Condition C. The stimuli appeared in location at the center of the 7" (17.8 cm) high by 9" (22.9 cm) wide CRT screen. A small luminous fixation point 1/8" (.32 cm) in diameter, placed 1/2" above the center of the stimulus

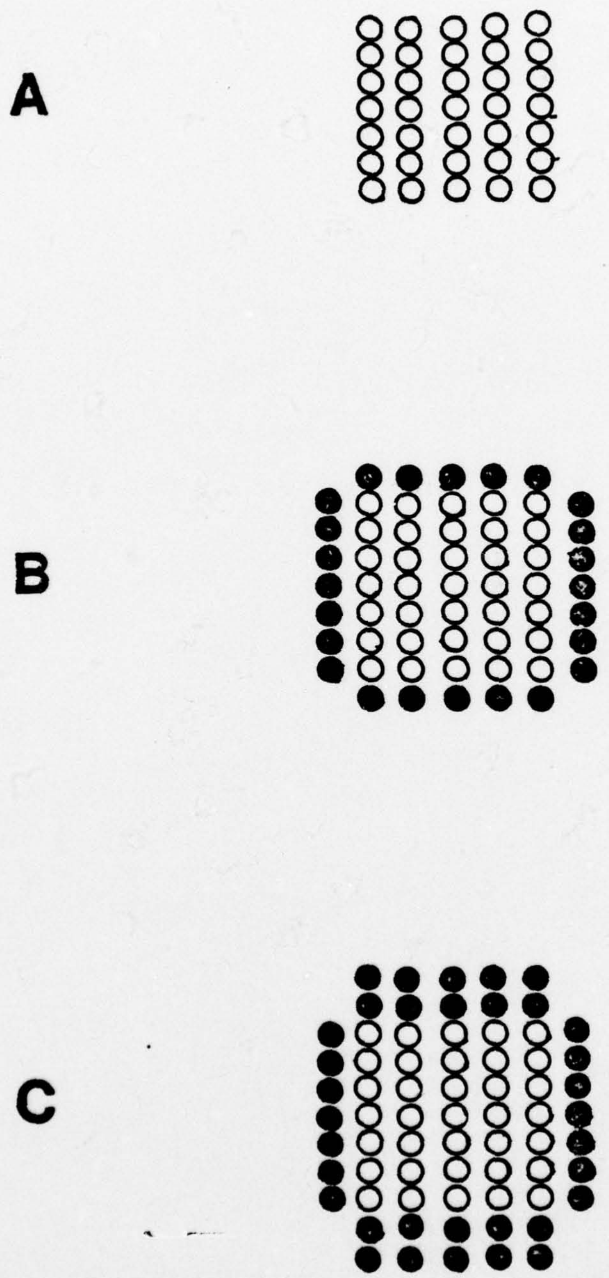

Figure 1 - Spatial arrangement of stimuli in Experiment II. The target stimuli (unfilled circles), always appeared first, followed by the masks (filled circles). All circles of light were solid greenish-yellow points of light (equal size) in the actual CRT displays.

array, was used to give subjects a position upon which to focus their eyes between presentations. The instructions asked subjects to focus directly below the fixation point between and prior to the start of presentations. The were asked to silently count the number of presentations. The counting procedure was used to help insure subject concentration in this tedious task. The recording from O_z should cancel the possible influence of language functions (counting) upon the VEP since it is over the juncture of left and right hemispheres. The subjects were asked to avoid excessive movement or eye blink during presentations of stimuli. In the experiment proper, 100 presentations were given at the end of which subjects were asked to draw a diagram of what they saw in any single presentation.

The three conditions were completely counterbalanced across the six subjects, over a period of three days, using a Latin-Square design. Each subject was presented with each condition six times during the course of three experimental sessions, for a total of 17 trials and 18 VEP traces from O_z. This method proved useful in reducing fatigue while also increasing the amount of data collected on each subject.

RESULTS

A summary of the perceptual reports indicates the following for each of the conditions:

Condition A- All six subjects saw one grid (one grid presented)

Condition B- Five subjects did not see the grid at all while one subject saw fragments of the Target grid (one grid and six lines presented)

Condition C- Five subjects did not see the grid, while

one subject saw fragments of the Target
Grid (one Grid and six lines presented)

Thus, all subjects saw what was expected in Condition A, while five of six subjects experienced complete masking in Conditions B and C. Did the perceptual effects observed have VEP correlates? This question can be answered through an analysis of the VEPs with respect to both amplitude and latency. The mean amplitudes and latencies for each of the major VEP components (N1, P1, N2 and P2) were computed for each condition for each of the six subjects from the X-Y tracings, as outlined in Experiment I. The mean amplitudes of the various VEP components obtained for each stimulus condition, across the six subjects, are shown in Table 1 for O_z and are illustrated in Figure 2.

Table 1

Mean Amplitude (μV) for Major VEp Components, Conditions A, B and C (N = 6)

VEP Component	Conditions A	B	C
N1	1.80	1.70	1.50
P1	4.20	4.50	4.60
N2	5.10	4.92	4.82
P2	6.30	4.70	4.59

The mean latencies for the various VEP components are presented in Table 2 and illustrated in Figure 3.

The data in Table 1 indicates greater amplitude VEPs to

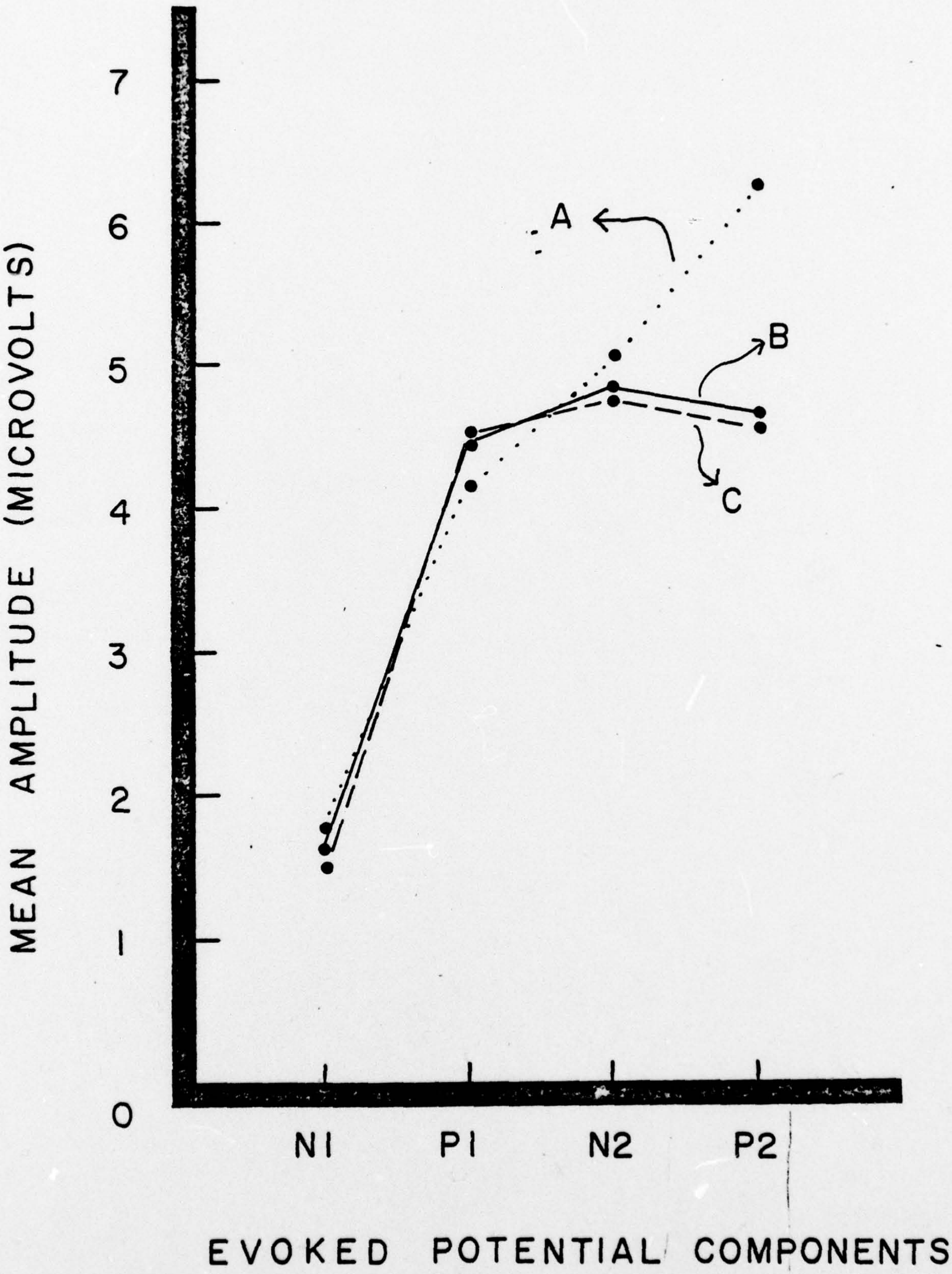

Figure 2 - Mean amplitude of the major VEP components (6 Ss) under Conditions A, B and C.

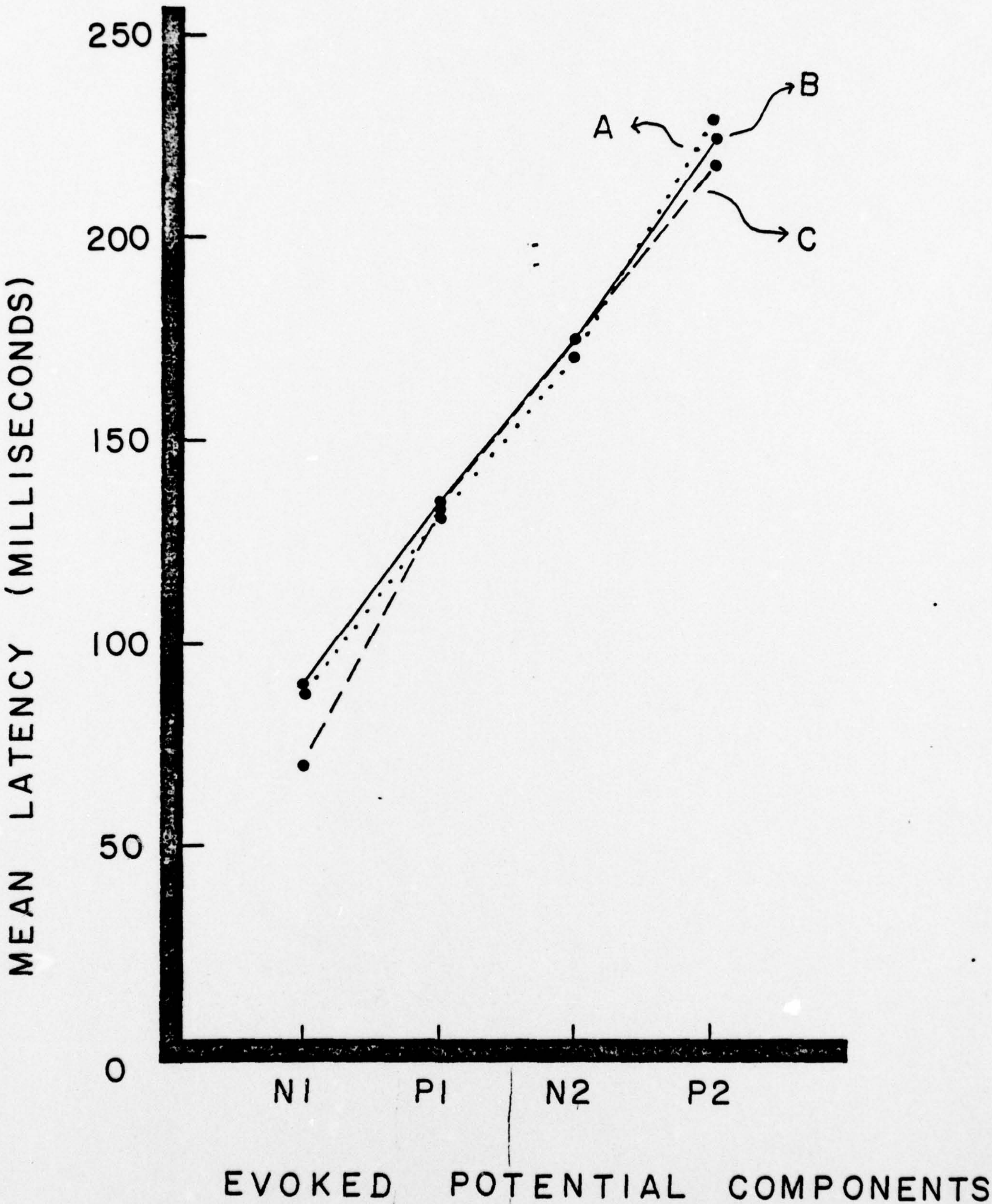

Figure 3 - Mean latency of the major VEP components (6 Ss) under Conditions A, B and C.

unmasked (Condition A) than masked Targets (Conditions B and C), especially for the P2 component. The amplitude for the two major components, N2 and P2, were tested for differences between conditions, using t-tests for correlated data (two-tailed criterion). For N2 amplitude, A vs. B, A vs. C, and B vs. C, none of the comparisons were significant ($p > .05$, 5 df). For P2 amplitude: A vs. B ($t = 2.81$, $p < .05$, 5 df); A vs. C ($t = 2.63$, $p < .05$, 5 df; B vs. C ($t = .24$, $p > .05$, 5 df). Thus, the major VEP component P2 showed significant amplitude attenuation under Conditions B and C when compared with Condition A, i.e., backward visual masking was accompanied by VEP attenuation.

Table 2

Mean Latency (msec) for Major VEP Components, Conditions A, B and C (N = 6)

VEP Component	Condition A	Condition B	Condition C
N1	87	89	70
P1	133	135	134
N2	177	179	179
P2	230	227	224

The latency data were also analyzed by t-tests for correlated data, two-tailed criterion, and none of the comparisons resulted in significant values ($p > .05$, 5 df).

Figure 4 shows the superimposed traces of one person (J.L.A.)

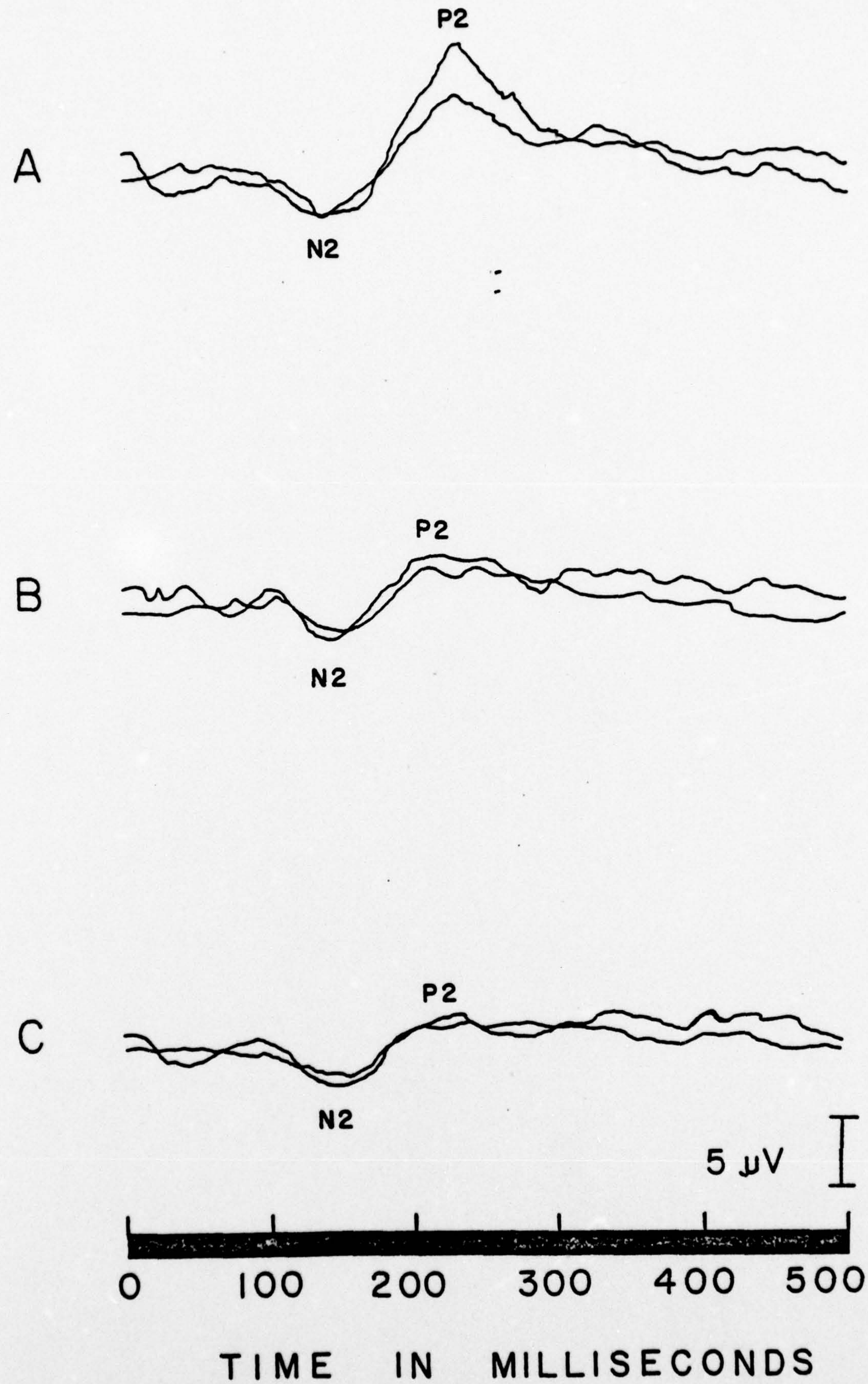

Figure 4 - Superimposed VEP traces for one subject. Each trace is based on 100 presentations. (Negativity is downward).

for one day. The mean P2 amplitude for this subject under Condition A was 9.08 μV, 5.33 μV under Condition B, and 5.08 μV under Condition C.

DISCUSSION

The results of the present experiment indicate that when backward masking occurred, there was a significant decrease in VEP amplitude. These results are similar to those of Vaughan and Silverstein (1968) and Andreassi et al. (1976a) who, respectively, reported attenuation of VEP amplitudes to foveal stimulation during metacontrast suppression and a backward masking paradigm using successive sets of like stimuli (Grids). On the other hand, our findings differ from those of Schiller and Chorover (1966) who did not find VEP changes under conditions of metacontrast. Vaughan and Silverstein (1968) have previously pointed out that this was possibly due to parafoveal stimulation which gave rise to VEPs generated largely by stray light impinging on the fovea.

The results of the present experiment are not like those of the visual masking experiments reported by Donchin et al. (1963). Donchin and Lindsley (1965) and Fehmi et al. (1969) in which VEPs were found to occur in response to the Mask, rather than the Target stimulus. However, in these studies the Mask was of much greater intensity than the Target (from 100 to 10,000 times) while in the present experiment, Masks were lower in intensity than the Target stimuli. Also, the SOA

which produced visual masking and complete VEP suppression was 20 msec or less in the Fehmi et al. (1969) study compared to a 60 msec SOA in the present study. These differences may possibly account for the different VEP effects obtained. Fehmi et al. (1969) showed that complete suppression of the evoked potential to the first stimulus occured at the retinal as well as the lateral geniculate and visual cortical areas. Fehmi has noted, and the results of the present experiment may support the finding, that masking effects have been observed with SOAs which were long enough to preclude the possibility that the masking stimuli could overtake the target at the retinal level. The VEP attenuation in the present experiment could have been completely due to inhibition at the retinal level since the receptors there would have had time (60 msec) to respond to the initial stimulus before the second arrived. The present experimental findings would be more consistent with reports that metacontrast suppression becomes maximal at SOAs between 40 and 100 msec. It is possible that a certain amount of inhibition took place at various subcortical sites (e.g., lateral geniculate body, ascending reticular formation) as well as at the visual cortex. Andreassi et al. (1976b) found evidence for a functional relationship between amount of target-mask contour interaction and degree of VEP attenuation. That is, increasing amounts of contour interaction results in progressive VEP attenuation.

A possible explanation for the VEP amplitude changes

which occurred as a function of degree of target-mask contour interaction is that varying amounts of excitatory-inhibitory activity between groups of neurons take place at the level of the visual cortex. Thus, we suggest that when a stimulus is presented to the visual system it results in excitation being produced at a given location in the visual cortex. When similar stimuli follow the initial one closely in time and space, adjacent areas of the visual cortex are stimulated, resulting in a reduction in response to the first stimulus. This inhibitory activity is not sufficient to eliminate the VEP completely, but enough to reduce it significantly, and, it would appear from the results of the present experiment, that the degree of VEP reduction might be related to the degree of bounding of the first stimulus by later ones. This excitatory-inhibitory hypothesis may explain the VEP attenuation and the visual masking observed in the present experiment, and the earlier ones of Vaughan and Silverstein (1968) and Andreassi et al. (1976a). The results of the present experiment emphasize the importance of closely adjacent contours in producing masking and VEP attenuation. Previous studies have shown that masks of greater area than targets, spatially removed, do not have significant masking or VEP effects (e.g., Andreassi et al. 1976b, Experiment II).

There are a number of lines of evidence which would seem to lend support to a cortical excitatory-inhibitory interaction hypothesis. For example, retinal projections are topograph-

ically organized at the level of the visual cortex, suggesting that patterns of light at the retina are translated into impulses at the visual cortex with elements of each pattern holding the same spatial relationship at the two areas (Ruch, 1965). Also, lateral inhibitory activities take place at the retinal level since impulses from a receptor are reduced in rate when neighboring receptors are simultaneously stimulated (Hartline, 1969). That lateral inhibitory effects can take place at the visual cortex is suggested by Hubel and Wiesel's (1959, 1962, 1968) studies in which they have identified cortical cells of a simple, complex and hypercomplex variety which are involved in both inhibitory and excitatory activities. Finally, experiments to test the feasibility of visual cortical prostheses with blind patients provide some suggestive evidence that lateral inhibition can take place in the human brain (Brindley & Lewin, 1968; Dobelle & Mladejovsky, 1974). Electrically produced phosphenes, or sensations of light, seemed to interact when two adjacent portions of the visual cortex were stimulated (Dobelle, Mladejovsky & Girvin, 1974). Simultaneous or sequential stimulation of two adjacent areas resulted in reports by patients of one phosphene instead of two.

It is possible that the kinds of excitatory-inhibitory processes proposed at the visual cortical level also occur at other locations of the visual system such as the lateral geniculate nucleus or the visual radiations, but we lack recordings

from these areas. The results from our study using surface electrodes indicate that increasing amounts of target-mask contour interaction results in increased amounts of VEP amplitude attenuation and subjective backward masking.

Experiment III: Backward Masking Produced by Corner Contours and its Effect on the VEP

This experiment will examine the effects of two mask sizes upon perception and the VEP. The mask sizes will represent 29% and 57% of the target area as compared to 68% and 97% in Experiment II. Another difference involves the mask location, i.e., they appear in such a manner that they border either two or four corners of the target. Thus, the basic question here concerns the effectiveness of mask area and orientation on perception and the VEP.

METHOD

Subjects: The subjects were three male and three female students and faculty associated with Baruch College of the City University of New York. None had visual defects other than myopia (corrected to at least 20/30).

Apparatus and Procedure: The apparatus and procedure for obtaining the VEP and EOG were the same as in Experiments I and II. The stimulus conditions, however, differed in the following manner: the stimuli were displayed on a Digital Equipment Corp. VR-14 which was mounted at the subject's eye level outside the Chamber at a distance of 51 inches (129.5 cm). The VR-14 CRT was controlled by the PDP-8/E digital computer which was programmed to deliver stimuli at specific times and locations upon the CRT. There were three

conditions comprised of (5 x 7) Grids and Lines that bounded the Grids at the corners:

Condition A- One Grid on the screen for 20 milliseconds (msec) (ON time of 20 msec)

Condition B- One Grid on the screen for 20 msec followed by Lines that bounded the Grid at two corners 60 msec later (ON time of 20 msec, OFF time of 60 msec)

Condition C- One Grid on the screen for 20 msec followed by Lines that bounded the Grid at all four corners 60 msec later (ON time of 20 msec, OFF time of 60 msec)

In every instance, there was always 1000 msec between each set of stimuli. For example, the Grid and four corners were presented in rapid succession, followed by a pause of 1000 msec before the next presentation of the Grid and corners.

The spatial arrangement in which the stimuli appeared upon the screen is represented schematically in Figure 1. The empty circles represent the Target stimuli, while the filled circles show the form of the Masking stimuli presented after the Target.

The single 1.0 cm square Grid produced a visual angle of 28' of arc in Condition A. In Conditions B and C the visual angle of the corner masks was 40' of arc. Therefore, in all conditions the presentations of the Target and Mask were

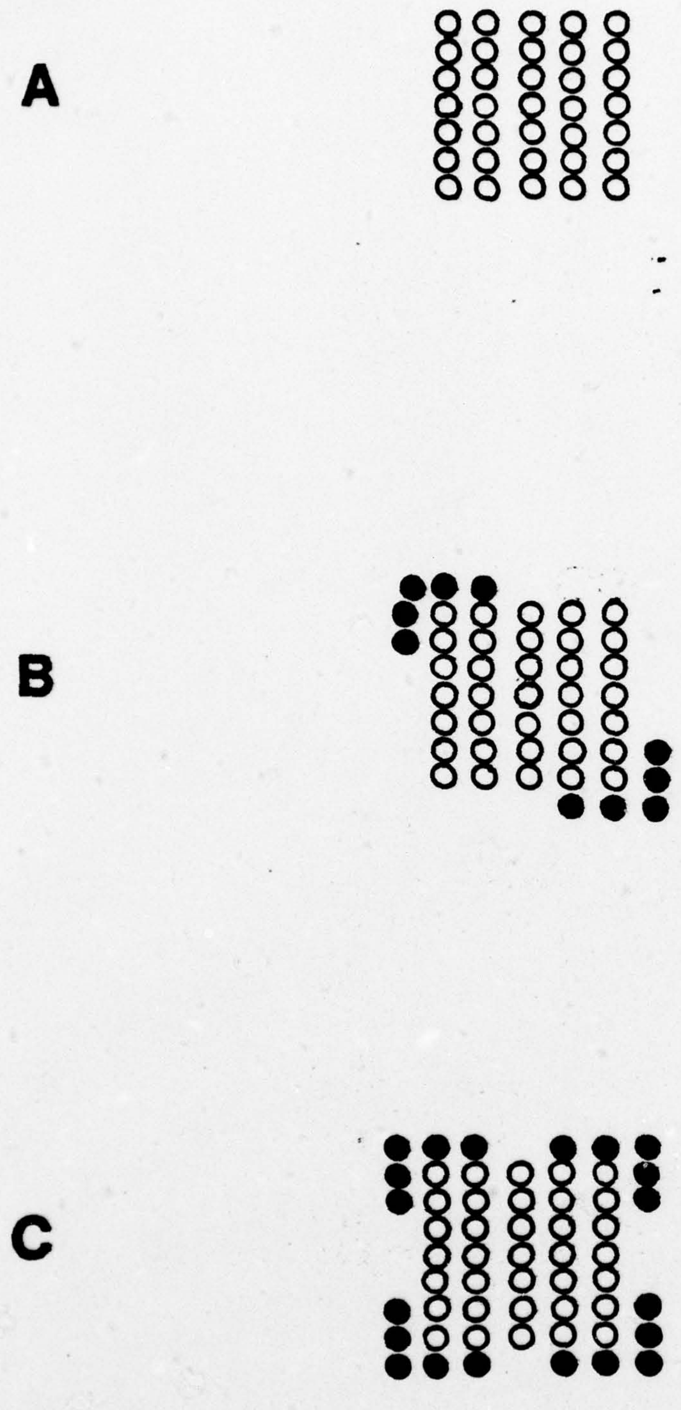

Figure 1 - Schematic of targets (open circles) and masks (closed circles) as they appeared under the three conditions. The targets were always presented first, followed by the masks in the spatial orientations indicated.

foveal. A single Grid produced an intensity of 1.39 mL when measured at a distance of 2.54 cm from the CRT screen surface with a Tektronix J-16 digital photometer (with the display intensity control set to maximum). The intensity of the masking corners in Conditions B and C were .93 mL. Thus, in Conditions B and C the Target intensity was greater than that of the mask.

The stimuli appeared in locations at the center of the 7" (17.8 cm) high by 9" (22.9 cm) wide CRT screen. A small luminous fixation point 1/8" (.32 cm in diameter), placed 1/2" above the center of the stimulus array, was used to give subjects a position upon which to focus their eyes between presentations.

The subjects were asked to focus directly below the fixation point between and prior to the start of presentations. They were asked to silently count the number of presentations. The subjects were asked to avoid excessive movement or eye blink during presentations of stimuli. In the experiment proper, 100 presentations were given, at the end of which subjects were asked to draw what they saw in any single presentation.

The three conditions were completely counterbalanced across six subjects, over a period of three days, using a Latin-Square design. Each subject was presented with each condition six times during the course of three experimental sessions, for a total of 18 trials and 18 VEP traces from O_z. This method proved useful in reducing fatigue while also

increasing the amount of data collected on each subject.

RESULTS

A summary of the perceptual reports indicates the following for each condition:

Condition A- All six subjects saw one Grid (one Grid presented)

Condition B- Three subjects saw two corners plus fragments of a Grid and three subjects saw two corners only (one Grid and two corners presented)

Condition C- Two subjects saw four corners and fragments of a Gird and four subjects saw four corners only (one Grid and four corners presented)

Thus, all subjects saw what was expected in Condition A, while three subjects experienced complete masking under Condition B and three reported partial masking. The reports for Condition C indicated complete masking in four individuals and partial masking for the other two.

Did these perceptual effects have VEP correlates? This question must be answered through an analysis of the VEPs with respect to both amplitude and latency. The mean amplitude was computed on the peak from N2 to P2. Latencies were computed for the P2 peaks. The N2 and P2 components were identified as described previously in Experiments I and II.

Table 1 shows the mean amplitude for the N2-P2 component across six subjects for Conditions A, B and C. Figure 2 depicts the amplitude data for N2-P2.

Table 1

Mean Amplitude (μV) for the VEP Component
N2-P2, Conditions A, B and C
(N = 6)

VEP Component	Condition A	Condition B	Condition C
N2-P2	8.50	6.75	5.82

Table 2 shows the mean latency for the N2 component across six subjects for Conditions A, B and C. Figure 3 depicts the data in Table 2.

Table 2

Mean Latencies (msec) for P2 Component
Conditions A, B and C
(N = 6)

VEP Component	Condition A	Condition B	Condition C
P2	205	207	204

The mean amplitude and latency data for the P2 component were tested for differences between conditions using t-tests for correlated data.

The results of the t-tests for P2 amplitude were: A vs.

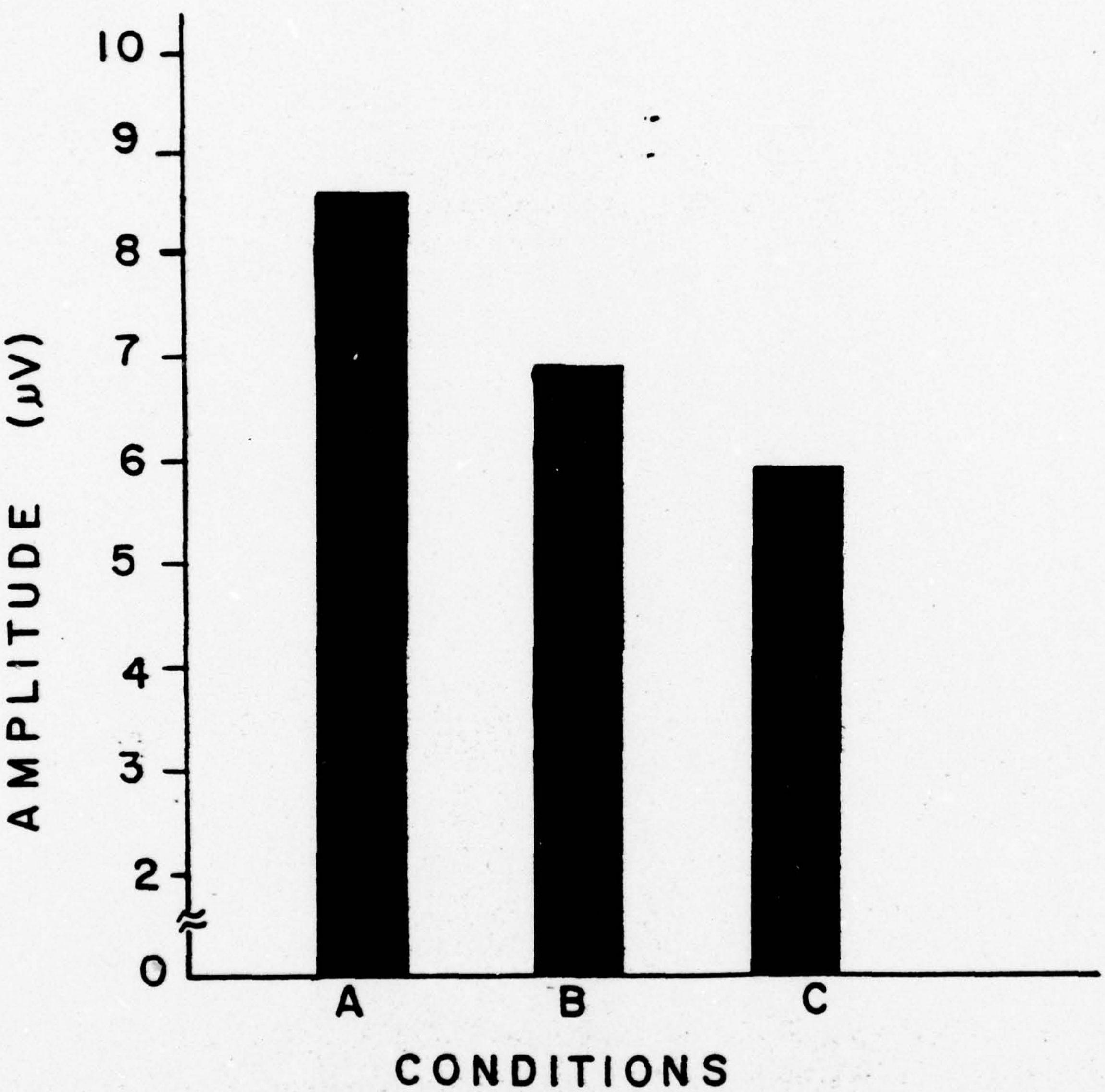

Figure 2 - Mean amplitude of the N2-P2 component of the VEP to target stimulus. (The means and standard deviations are, respectively, A = 8.50 and 2.31; B = 6.75 and 1.35; C = 5.82 and 1.06.)

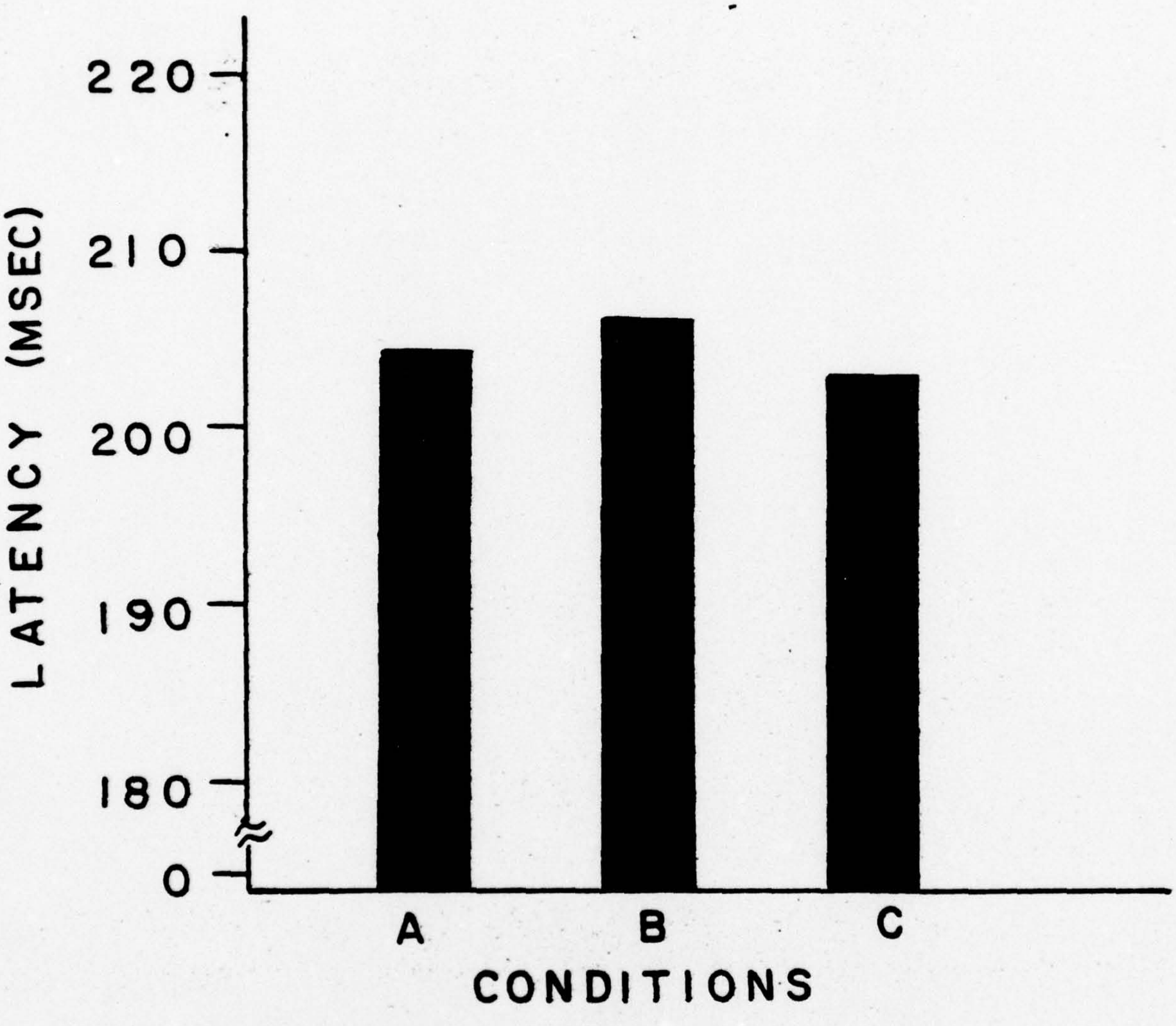

Figure 3 - Mean latency of the P2 component of VEP to target stimulus, Conditions A, B, and C.

B ($t = 2.42$, $p > .05$, 5 df); A vs. C ($t = 3.39$, $p < .02$, 5 df); B vs. C ($t = 1.98$, $p > .05$, 5 df). Thus, the major VEP component P2 to the target stimulus showed significant attenuation when it was followed by a four-corner mask. The results of the t-tests for the P2 component of the latency data showed that none of the comparisons were significant ($p > .05$, 5 df).

Figure 4 shows the superimposed traces of one person (M.L.) for one day. This subject had a mean P2 amplitude of 9.00 μV under Condition A, 6.33 μV under Condition B, and 6.75 μV under Condition C.

DISCUSSION

The results of the present experiment show that a mask which is 57% of target size can produce perceptual effects and VEP amplitude attenuation (Condition C). In Condition B, where the target was bounded at only two corners, masking was not as effective and the VEP to the target did not decrease significantly. (In Condition B the mask was 29% of the target area.) These results are similar to those of Vaughan and Silverstein (1968) who reported attenuation of the VEP amplitudes to foveal stimulation during metacontrast suppression, to Andreassi et al. (1976a) who reported VEP amplitude attenuation using a backward masking paradigm, and to Experiment II of the present report.

The major differences in the present experiment when compared to Experiment II are that (1) the mask was placed at the corners of the target stimulus as opposed to the mask

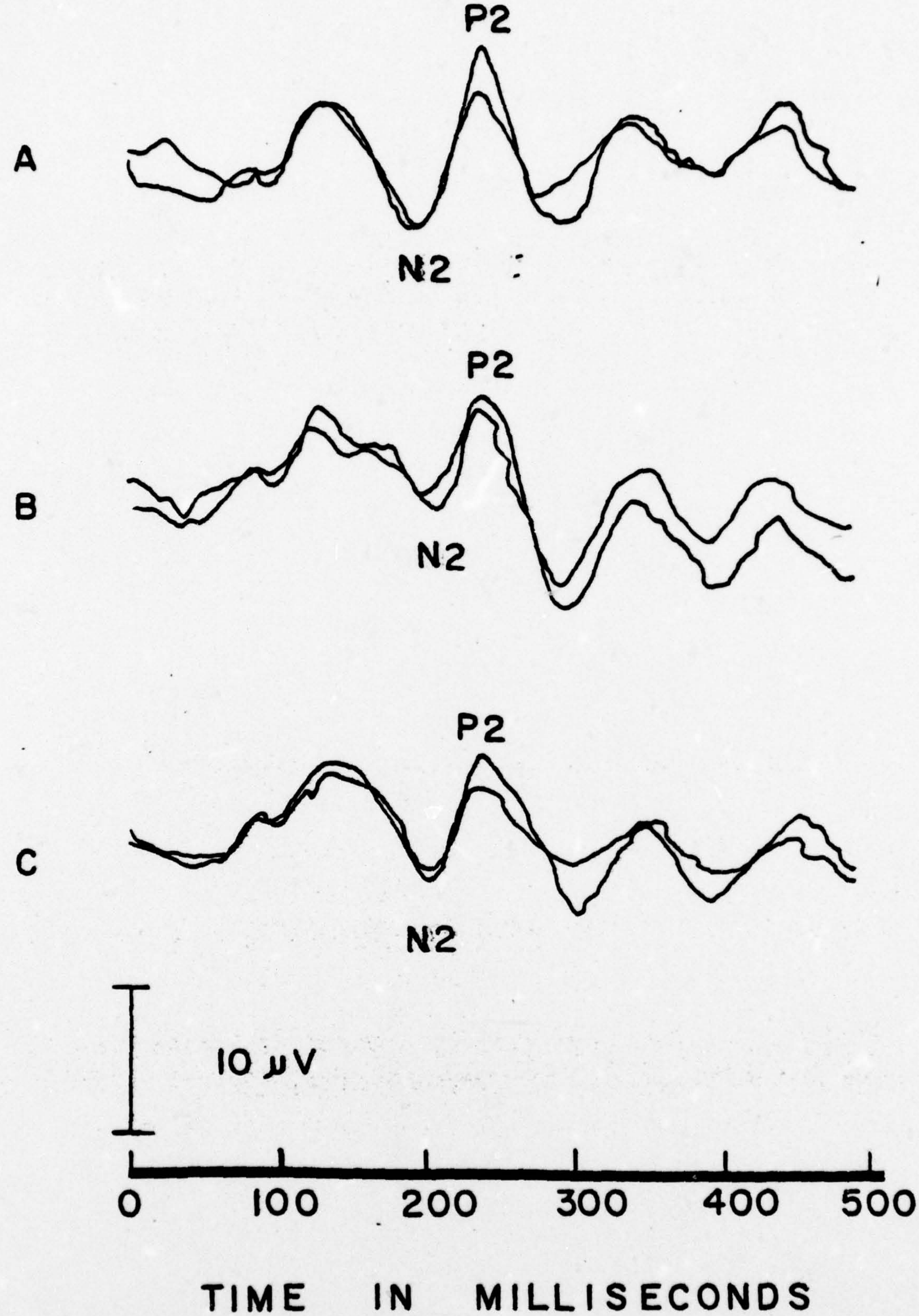

Figure 4 - Superimposed VEP traces for one subject. Each trace is based on 100 presentations (negativity is downward.)

bounding the target along the length of its contour, and (2) the masks were 29% and 57% of the target area while in Experiment II, the masks were 68% and 97% of the target area. Thus, it is not only possible to achieve perceptual masking with masks which cover less area than targets, but it is also possible to obtain significant VEP attenuation associated with such perceptual effects.

A possible explanatory mechanism proposed for earlier findings (Andreassi et al., 1971, 1974, 1976a) may at least partially account for the findings of the present experiment. That is, when a stimulus is presented to the visual system, it results in excitation at the cortex. When similar stimuli follow the initial one closely in time and space, adjacent areas of the visual cortex are stimulated, resulting in a reduction in response to the first stimulus. This inhibitory activity is not sufficient to eliminate the VEP completely, but enough to reduce it significantly. Thus, in Condition B the inhibitory activity produced by the two masking corners was not sufficient to significantly decrease the VEP. The two-corner mask, therefore, may not have produced sufficient contour interaction in the visual system to significantly reduce the VEP. In Condition C the contour interaction produced by the four corners was sufficient to decrease the VEP to the target stimulus. We propose that this inhibitory activity occurred at the level of the visual cortex in a manner outlined in our discussion of Experiment II.

Experiment IV: A Comparison of Corner and No Corner Contours as Masking Stimuli

In the previous experiment (Experiment III) we examined the effects of two corners versus four contours as masking stimuli. The two-corner masks (upper left and lower right) led to partial perceptual masking, but no significant VEP amplitude decrease. However, four-corner masks produced perceptual masking in all subjects and a corresponding decrease in VEP magnitude. The two-corner mask was 29% of the target area, while the four-corner mask occupied 57% of the target stimulus area. Thus, the area of the mask, or amount of contour interaction between target and mask, was related to both degree of perceptual masking and VEP decrement.

The question to be addressed in the present experiment concerns the relative effectiveness of similar area corner and non-corner stimuli as masks. That is, if a mask is constructed to interact with four corners of a target will it be more or less effective than a mask which interacts with the target at points other than the corners? Both corner masks and non-corner masks are designed to occupy an area equivalent to 57% of the target area. Thus, in no case is the mask greater in area than the target.

METHOD

Subjects: The subjects were three males and three females associated with the City University of New York. None had any visual defects other than myopia (corrected to at least 20/25).

Apparatus and Procedure: The subjects were seated in an electrically shielded sound-attenuated room (IAC Chamber). The VEP was obtained from O_z and the procedure for obtaining it was identical to that used in the previous experiment, except for the specific stimuli used. The stimuli were displayed on a Digital Equipment Corp. VR-14 CRT which was mounted at the subject's eye level outside the IAC Chamber at a distance of 129.5 cm (51 inches). The VR-14 CRT was controlled by the PDP 8/E digital computer and was programmed to deliver stimuli at specific times and locations upon the CRT. There were three conditions:

Condition A - One grid on the screen for 20 msec (ON time of 20 msec)

Condition B - One grid on the screen for 20 msec, followed by four surrounding lines, 40 msec after the grid disappeared. (ON time 20 msec, OFF time 40 msec)

Condition C - One grid on the screen for 20 msec, followed by lines that bounded the grid at all four corners, 40 msec after the grid disappeared (ON time 20 msec, OFF tiem 40 msec)

In every instance, there was always 1000 msec between each set of stimuli. For example, a grid and four corners were presented in rapid succession, followed by a pause of 1000 msec before the next presentation of the grid and corner combination.

The spatial arrangement in which the stimuli appeared upon the CRT screen is represented schematically in Figure 1. The empty circles represent the target stimuli, while the filled circles show the form of the masking stimuli presented after the target.

The single 1.0 cm square grid produced a visual angle of 28' of arc in Condition A. In Condition B the visual angle of the masking corners covered an extent equal to 42' of arc while non-corner masks covered 40' of arc in Condition C. Therefore, in all conditions the presentation of the target and mask did not exceed foveal extent, since the foveal is estimated at 2.5 degrees of arc (Ruch, et al. 1966). A single grid produced an intensity of 1.39 mL when measured at a distance of 2.54 cm from the CRT screen surface with a Tektronix J-16 digital photometer (with the display intensity control set to maximum). The intensity of the masking corners in Condition B and C were .929 mL. Thus, in all conditions the target intensity was greater than the mask intensity.

The stimuli appeared in locations at the center of the 7" (17.8 cm) high by 9" (22.9 cm) wide CRT screen. A small

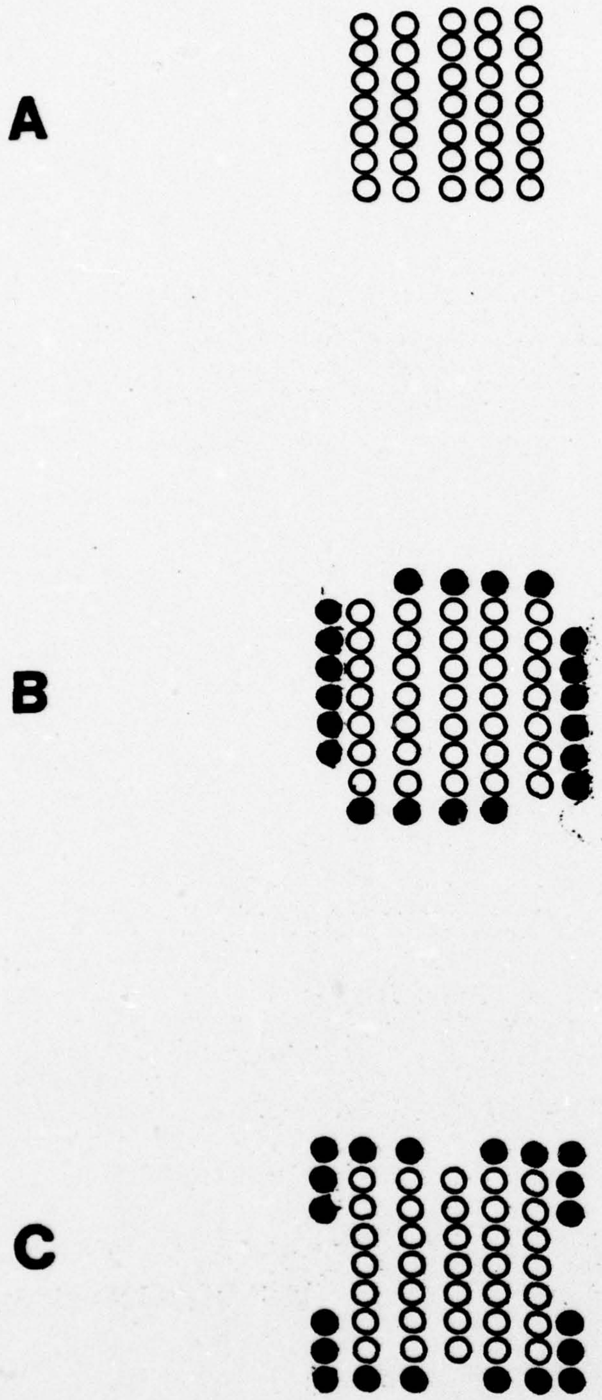

Figure 1 Schematic of targets (open circles) and masks (closed circles) as they appeared under the three conditions. The targets were always presented first, followed by the masks in the spatial orientations indicated.

luminous fixation point 1/8" (.32 cm) in diameter placed 1/2" above the center of the stimulus array, was used to give subjects a position upon which to focus their eyes between presentations.

The instructions asked subjects to focus directly below the fixation point between and prior to the start of presentations. They were asked to silently count the number of presentations. The counting procedure was used to help insure subject concentration in this tedious task. The recording from O_z should cancel the possible influence of language functions (counting) upon the VEP since it is over the juncture of left and right hemispheres. The subjects were asked to avoid movement and eye blinking during presentations of stimuli. In the experiment proper, 100 presentations were given at the end of which subjects were asked to draw what they observed in any single presentation.

The three conditions were completely counterbalanced across six subjects, over a period of three days, using a Latin-Square design. Each subject was presented with each condition six times during the course of three experimental sessions, for a total 18 trials and 18 VEP traces from O_z. This method proved useful in reducing fatigue while also increasing the amount of data collected on each subject.

RESULTS

A summary of the perceptual reports indicates the following for each condition:

Condition A - All six subjects saw one grid (one grid presented)

Condition B - All six subjects saw four lines (one grid and four lines presented)

Condition C - All six subjects saw four corners (one grid and four corners presented)

Thus, all subjects saw what was expected in Condition A, and all subjects experienced complete perceptual masking under Conditions B and C.

The mean amplitude and latency data were computed as in the previous experiment. These data are presented in Tables 1 and 2 and are graphically represented in Figures 2 and 3.

Table 1

Mean Amplitude (Microvolts) for the VEP Components N1-P1 and N2-P2 Under Conditions A, B and C (N = 6)

VEP Components	Conditions A	Conditions B	Conditions C
N1-P1	5.30	5.70	5.60
N2-P2	11.38	7.87	7.47

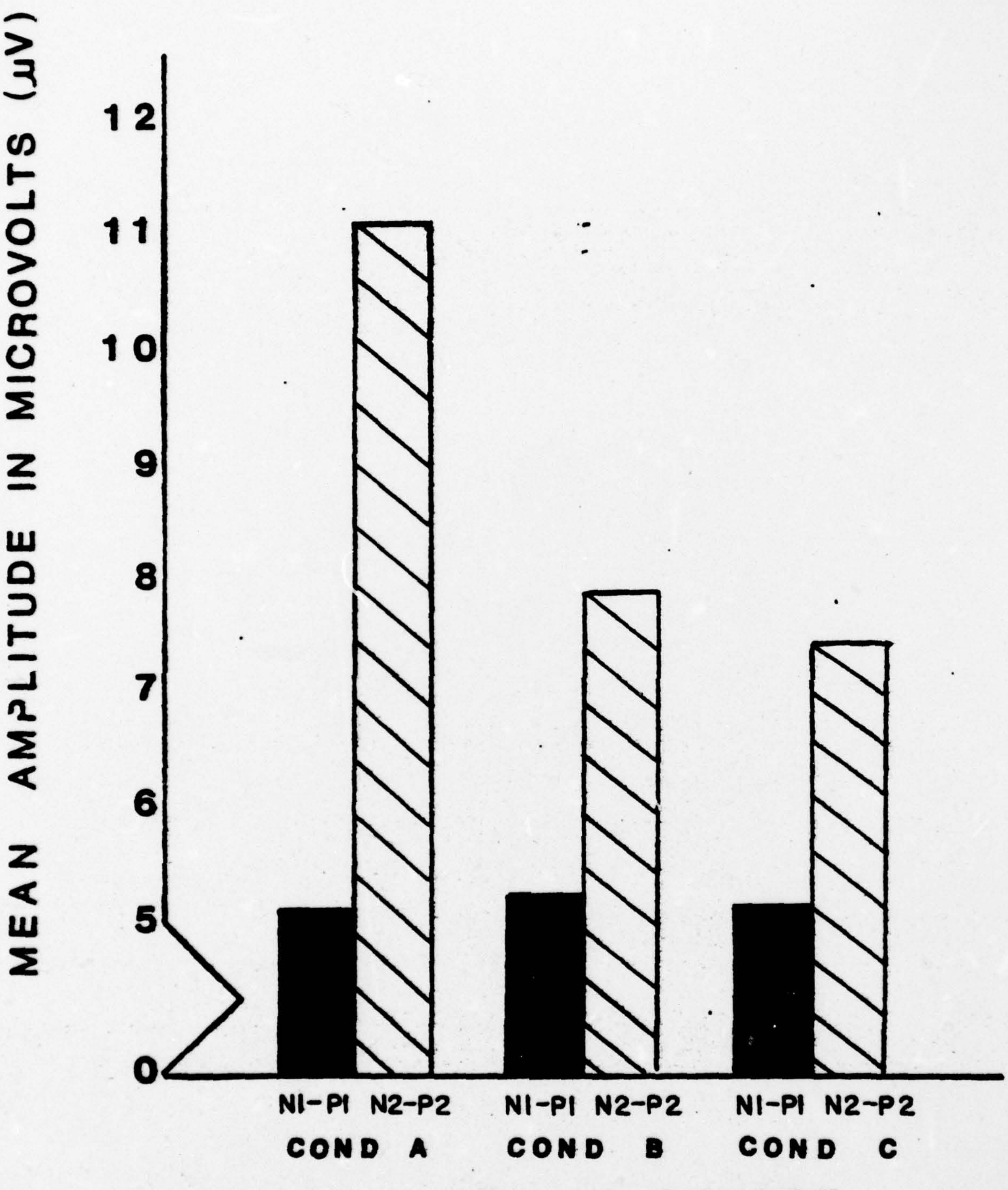

Figure 2- Mean amplitude of VEP components N1-P1 and N2-P2 under conditions A,B, and C (6 Ss).

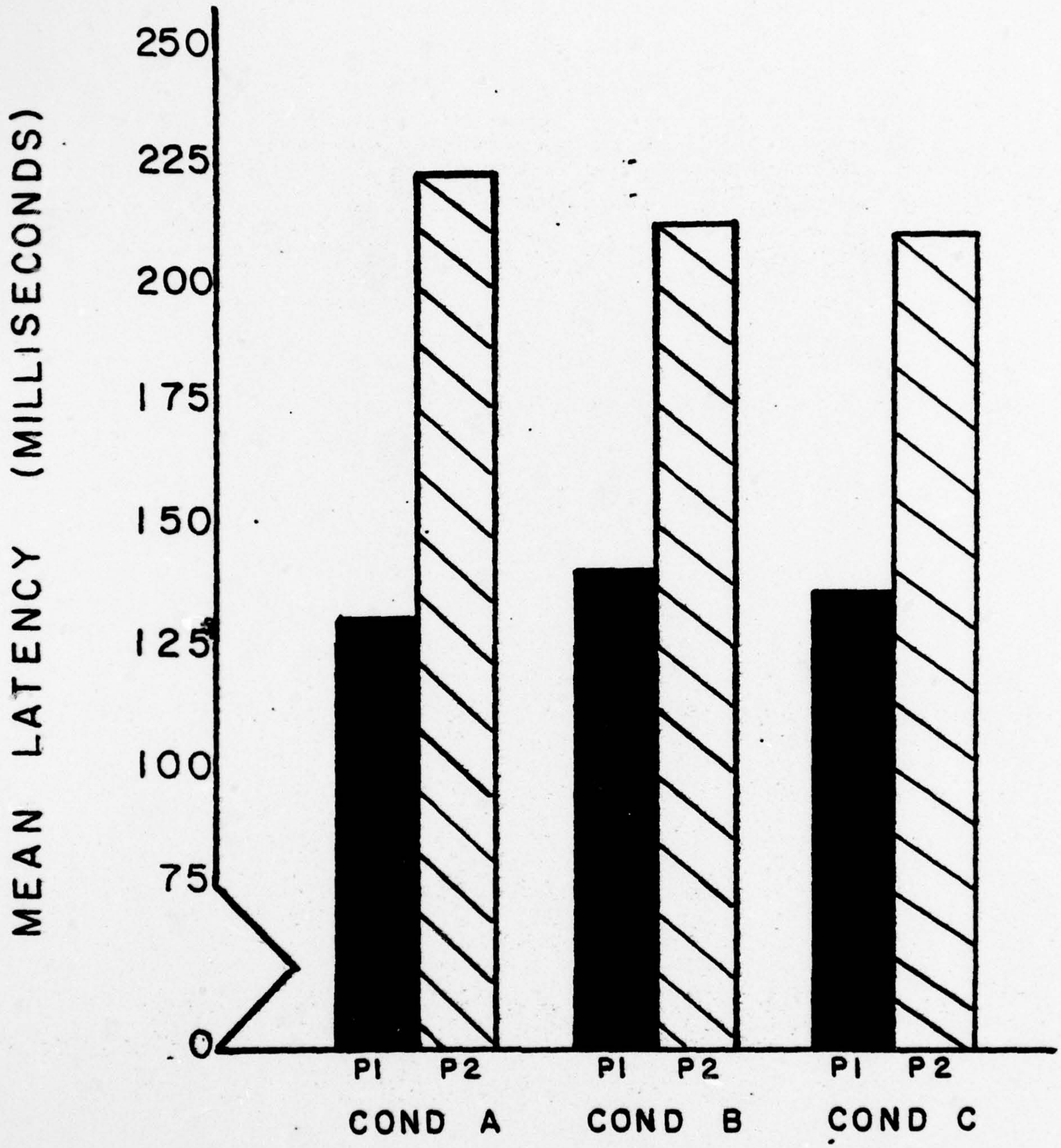

Figure 3 Mean latency for VEP components P1 and P2 under conditions A,B, and C.(6 Ss).

Table 2

Mean Latency (Milliseconds) of VEP Components, P1 and P2 Under Conditions A, B and C (N = 6)

VEP Components	Conditions A	B	C
P1	128	138	132
P2	225	217	216

The data for one VEP component (N2-P2) were subjected to analysis by t-tests for correlated data (two-tailed criterion, 5 df). The results of the tests for the amplitude data, N2-P2 component were: A vs. B ($t = 2.85$, $p < .05$); A vs. C ($t = 4.05$, $p < .01$) and B vs. C ($t = .73$, $p > .05$). The latency comparisons yielded no significant findings ($p > .05$).

The superimposed traces for one subject, R. K., are shown in Figure 4. This subject had a mean P2 amplitude of 15.25 µV under Conditon A, 10.80 µV under Condition B, and 10.90 µV under Condition C.

DISCUSSION

The results indicate that the non-corner and corner stimuli were equally effective in producing perceptual masking and attenuation of a major VEP component (N2-P2). This component (P2) occurred at approximately the same latency for all three conditions (200 msec) indicating that response latency to the target stimulus was not affected by the mask,

even though the VEP to the target was attenuated. The fact that there was no significance in N2-P2 amplitude with the corner vs. non-corner mask also attests to the similar effect which both had on the decrement in N2-P2 amplitude.

Thus, contour interaction between target and mask at the non-corner location is as effective as the corner location in producing perceptual and VEP effects. The basic explanation for the VEP and perceptual change is the same excitation-inhibition hypothesis proposed in explication of previous experimental results.

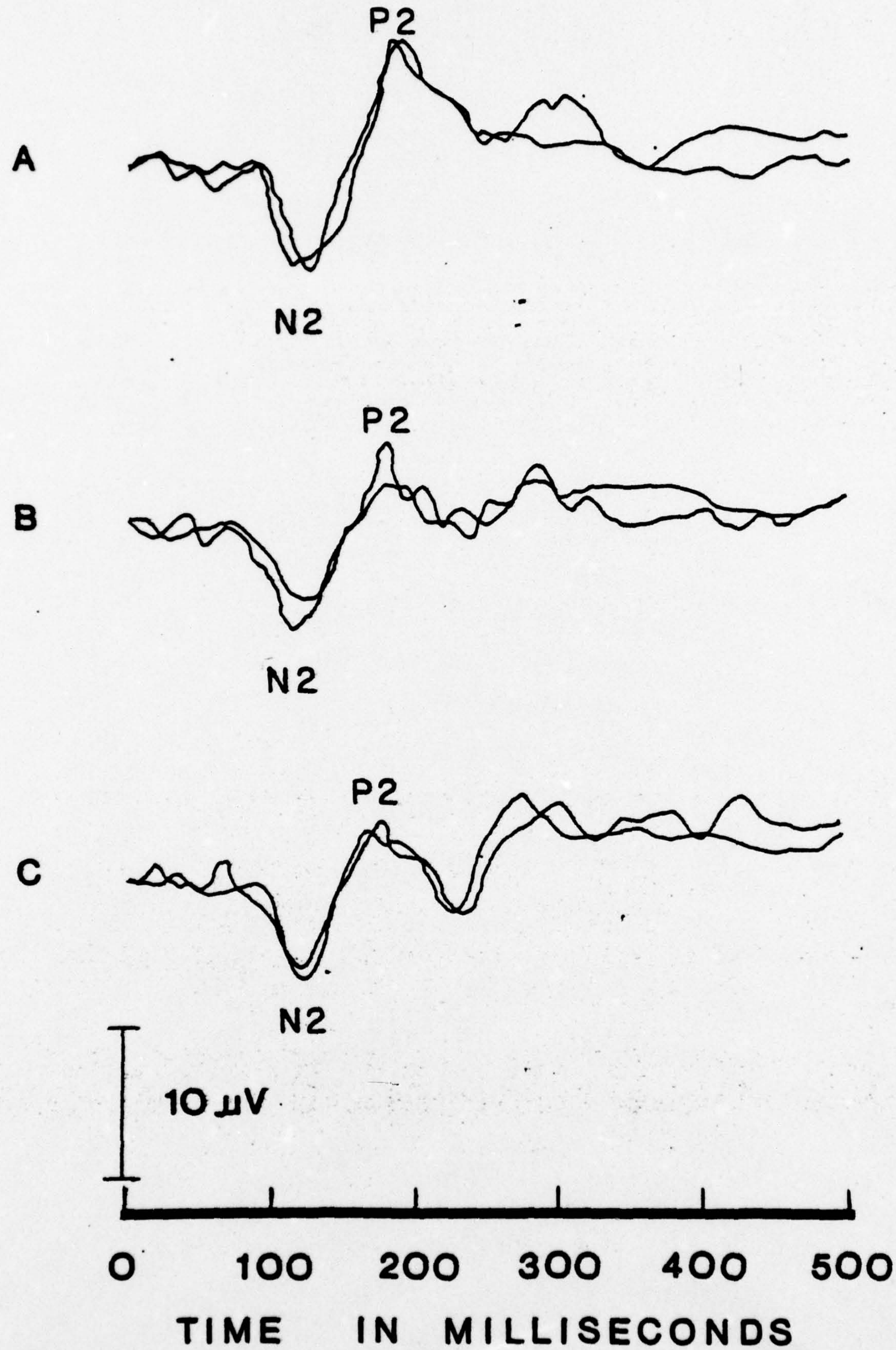

Figure 4- Superimposed traces for one subject (R.K.) under conditions A,B, and C. Negativity is downward.

Experiment V: Target Masking by Visual Noise and VEP Attenuation

The backward masking paradigms studied to date in this laboratory have involved patterned targets and masks. The question to be addressed here is the effect of an unpatterned mask* upon perception of, and VEPs generated by, a patterned target.

A brief enumeration of the target-mask stimuli which have produced perceptual masking of and VEP attenuation to the target stimulus is as follows:

1. Disc-ring paradigm (Vaughan & Silverstein, 1968).
2. Single sequential stimuli (Andreassi et al., 1971, 1974).
3. Multiple sequential stimuli (Andreassi, et al., 1976).

The findings from these studies led to the conclusion that variations in the type of masking stimuli used produce differential effects in terms of the strength of backward masking. The purpose of the present study was to determine the effect of an unpatterned mask on the perception of a target stimulus. There are two basic research questions:

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*The usage of unpatterned mask as used here refers to a random arrangement of elements as shown in Figure 1.

(1) What effect will the unpatterned mask have on the perception of the target? and (2) How will the event related visual potential, record from O_z (occipital) C_z (central) scalp locations, be affected?

METHOD

Subjects: The subjects were eight males and two females associated with the City University of New York. None had visual system defects other than myopia (corrected to at least 20/25).

Apparatus and Procedure: Subjects were seated in an electrically shielded sound-attenuated (IAC Chamber). All experimental sessions were conducted with the lights dimmed.

In order to obtain the averaged cortical evoked potential, the electroencephalogram (EEG) of each subject was recorded from O_z and C_z ("Ten-Twenty" System, Jasper, 1958) with Grass silver cup electrodes referenced to a silver clip electrode on the subject's left ear lobe. A Beckman Type RM Dynograph Recorder was used to record the EEG and a Mnemotron Computer of Averaged Transients (CAT 1000) was used to obtain the averaged evoked potential. The subject was grounded by means of an electrode attached to the right ear lobe leading to "patient ground" of the Beckman Dynograph. The 9806A coupler of the Dynograph was used to condition the EEG signal (bandpass set at 0.5 to 32.0 Hz). The filtered and amplified signal was then fed into the CAT. A "start" signal from a PDP-8/E digital computer triggered

the CAT to take EEG samples every 0.5 msec duration following the presentation of each stimulus to the subject. After 100 stimulus presentations, the summated VEP responses from CAT memory were plotted by a Hewlett-Packard X-Y Plotter.

The electro-oculogram (EOG) was measured by a separate channel of the Beckman Dynograph and averaged by the CAT as a check on possible distortions of the VEP due to excessive eye movement or eye blink. None of the trials had to be repeated because of VEP contamination by EOG.

The stimuli were displayed on a Digital Equipment Corp. VR-14 which was mounted at the subject's eye level outside the Chamber at a distance of 54 inches (137.2). The VR-14 CRT was controlled by the PDP-8/E digital computer which was programmed to deliver stimuli at specific times and locations upon the CRT. There were two conditions:

Condition A - One target letter "T" on the screen for 20 milliseconds (msec)

Condition B - One target letter "T" followed by an "Unpatterned Mask." (See Figure 1.) The "Unpatterned Mask" was presented 40 msec after the target "T" disappeared from the screen.*

Thus, all of the stimuli were on the screen for 20 msec,

*Disappearance was virtually immediate (50 sec) with the brief persistence P24 phosphor specially installed in the VR-14.

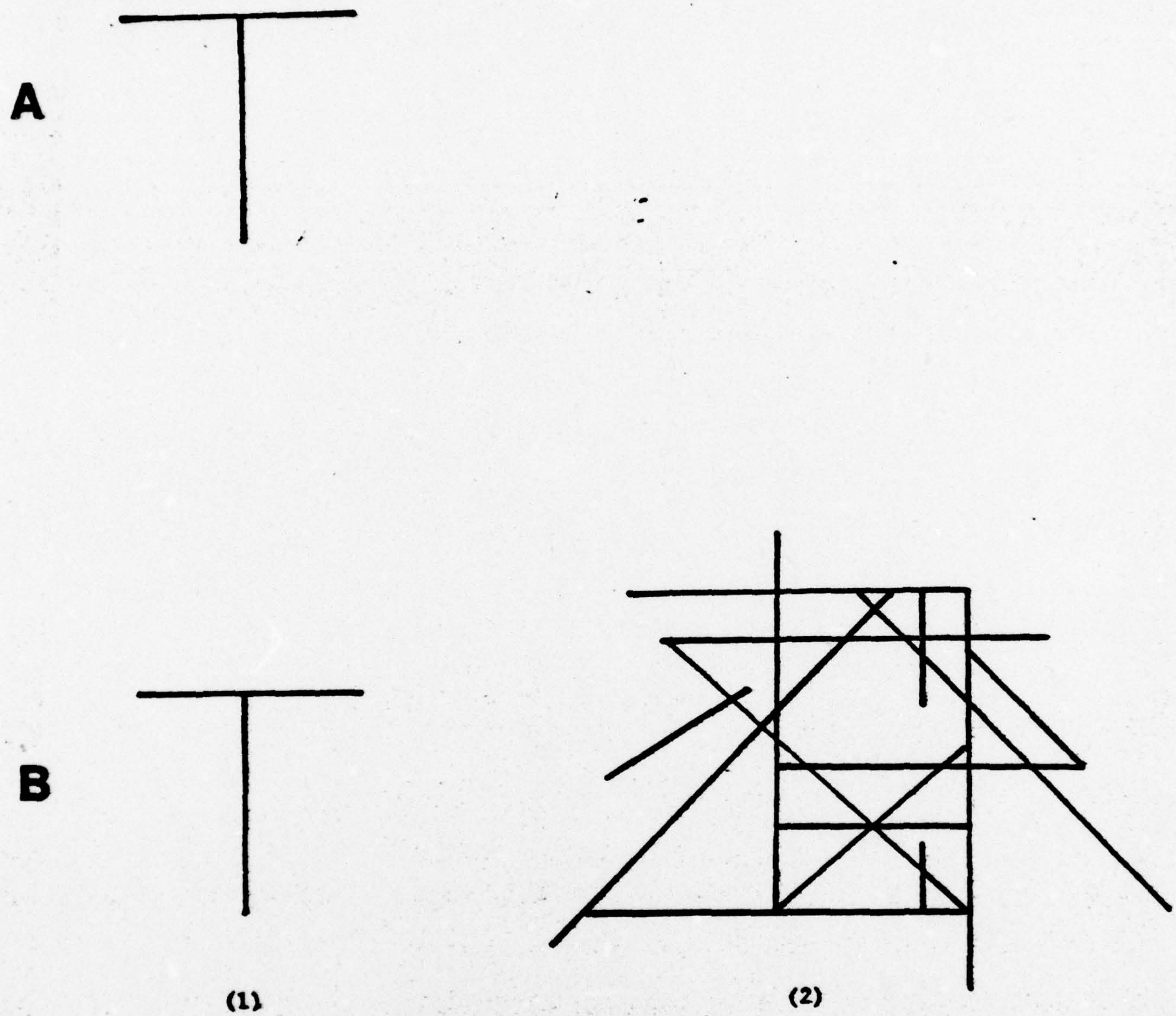

Figure 1- Schematic of conditions A and B. In condition B the unpatterned mask always followed the target (T) and overlapped it spatially.

and there was an ISI of 40 msec, i.e., 40 msec intervened between the disappearance of one stimulus and the appearance of the next upon the screen. In every instance there was always 1000 msec between each stimulus set. For example, a target T and its accompanying Unpatterned Mask were presented in rapid succession, followed by a pause of 1000 msec, after which the next set of T and Unpatterned Mask appeared. The luminance of the 1 cm square T was 2.04 mL (measured at the distance of 2.54 cm with a Tektronix J 16 Digital Photometer) and produced a visual angle of 26 min of arc. The Unpatterned Mask measured 2.32 mL and produced a visual angle of 39 min of arc in height and 1 deg 31 min of arc in length.

The stimuli appeared in locations at the center of the 7" (17.8 cm) high by 9" (22.9 cm) wide CRT screen. A small luminous fixation point 1/8" (.32 cm) in diameter, placed 1/2" above the center of the stimulus array, was used to give subjects a position upon which to focus their eyes between presentations.

The instructions asked subjects to focus directly below the fixation point between and prior to the start of presentations. They were asked to silently count the number of presentations. The counting procedure was used to help insure subject concentration in this tedious task. The recording from O_z should cancel the possible influence of language functions (counting) upon the VEP since it is over

the juncture of left and right hemispheres. The subjects were asked to avoid excessive movement or eye blink during presentations of stimuli. In the experiment proper, 100 presentations were given at the end of which subjects were asked to draw what they saw in any single presentation.

The two conditions were counter-balanced in an ABBA-BAAB sequence in one experimental session. With the single experimental session each subject was presented with each condition four times for a total of eight trials and eight VEP traces from O_z and C_z.

RESULTS

The perceptual reports and diagrams produced after each condition indicated that in Condition A all subjects saw the target letter "T" and in Condition B all subjects saw the unpatterned mask only. These results indicate that complete perceptual masking took place under Condition B. The question now arises as to whether these perceptual results have VEP correlates. This question can be answered through an analysis of amplitude and latencies. The mean amplitudes and latencies for each of the major VEP components (N1-P1, N2-P2) were computed for each condition over all subjects from the X-Y traces, as outlined in Experiment I. The mean amplitude of the various VEP components obtained for each stimulus, across the ten subjects, are shown in Table 1 for O_z and C_z and are illustrated in Figures 2 and 3.

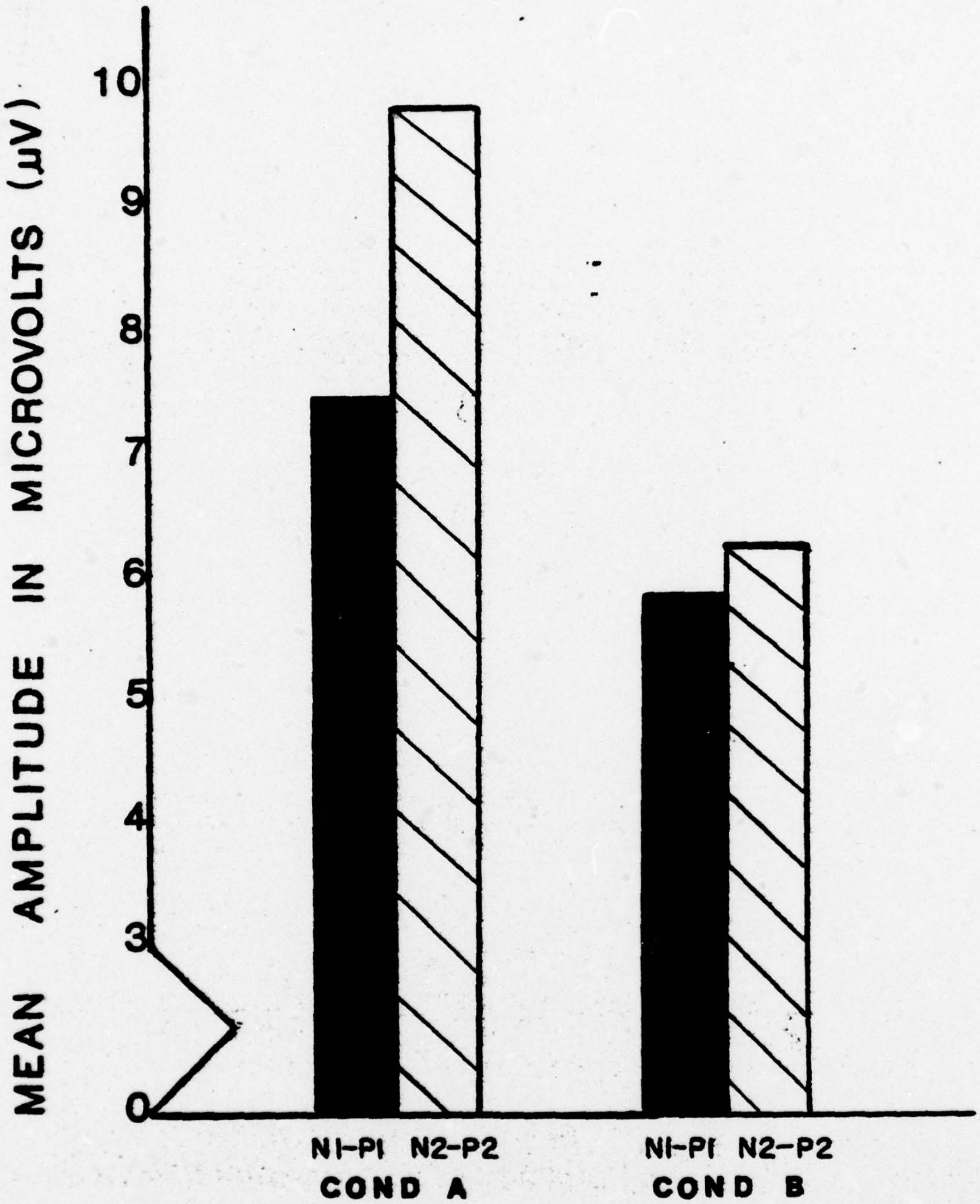

Figure 2- Mean amplitude for VEP components N1- P1 and N2-P2 under conditions A and B at O_z (10 Ss).

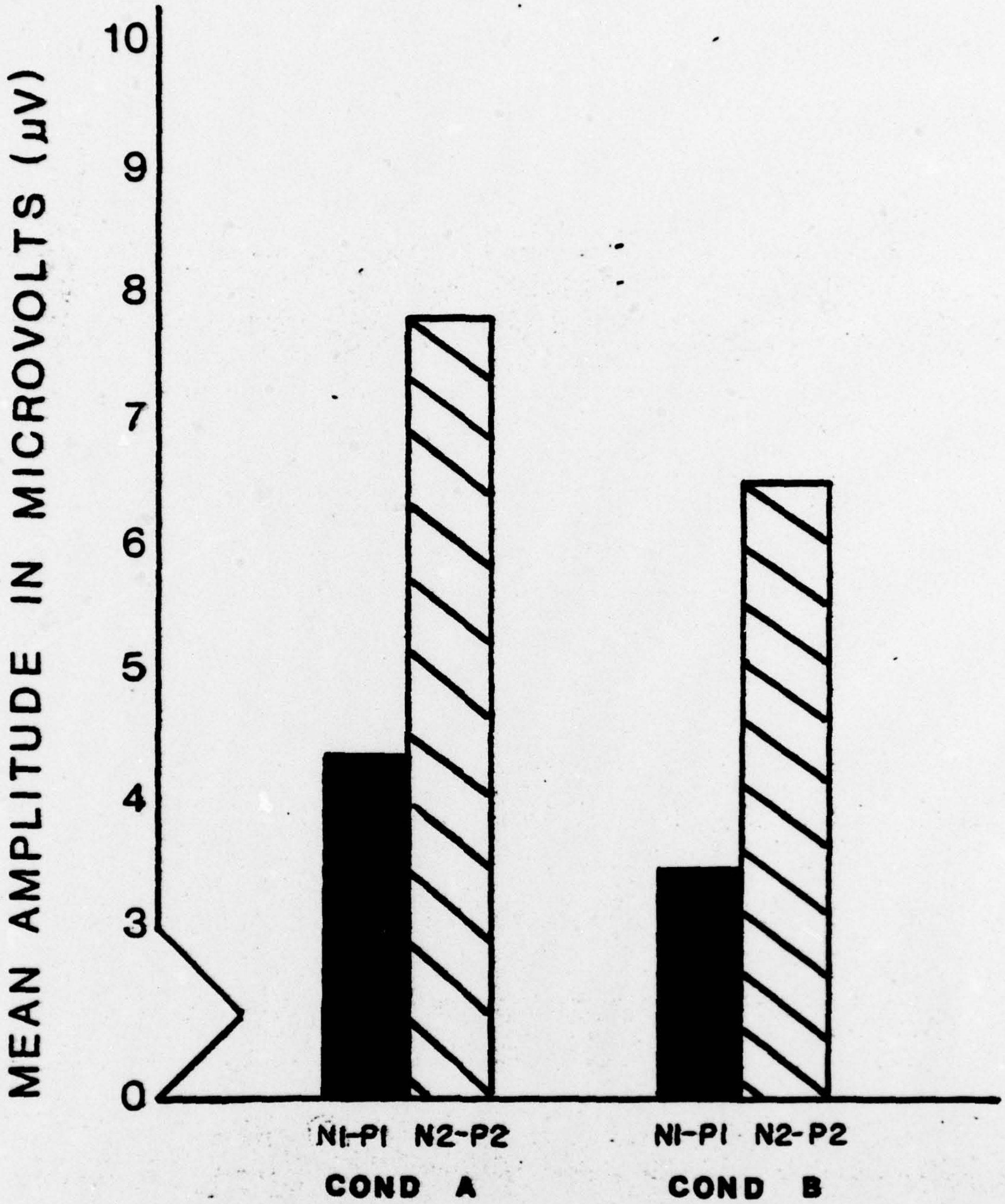

Figure 3- Mean amplitude for VEP components N1-P1 and N2-P2 under conditions A and B at C_z (10 Ss).

Table 1

Mean Amplitude (uV) for Major VEP Components, Conditions A and B (N = 10)

VEP Components	O_z Conditions		C_z Conditions	
	A	B	A	B
N1-P1	7.5	5.8	4.3	3.9
N2-P2	9.9	6.3	7.9	6.6

The mean latencies for the various VEP components are presented in Table 2 and illustrated in Figures 4 and 5.

Table 2

Mean Latency (msec) for Major VEP Components, Conditions A and B (N = 10)

VEP Components	O_z Conditions		C_z Conditions	
	A	B	A	B
P1	130	140	154	176
P2	223	227	259	269

The data in Table 1 indicate greater amplitude VEPs to the unmasked target (Condition A) than to the masked target (Condition B) especially for the N2-P2 component. The data for one VEP component* (N2-P2) were subjected to

*The N2-P2 component has proven to be the most consistent and reliable of the VEP measures under the conditions described in this report.

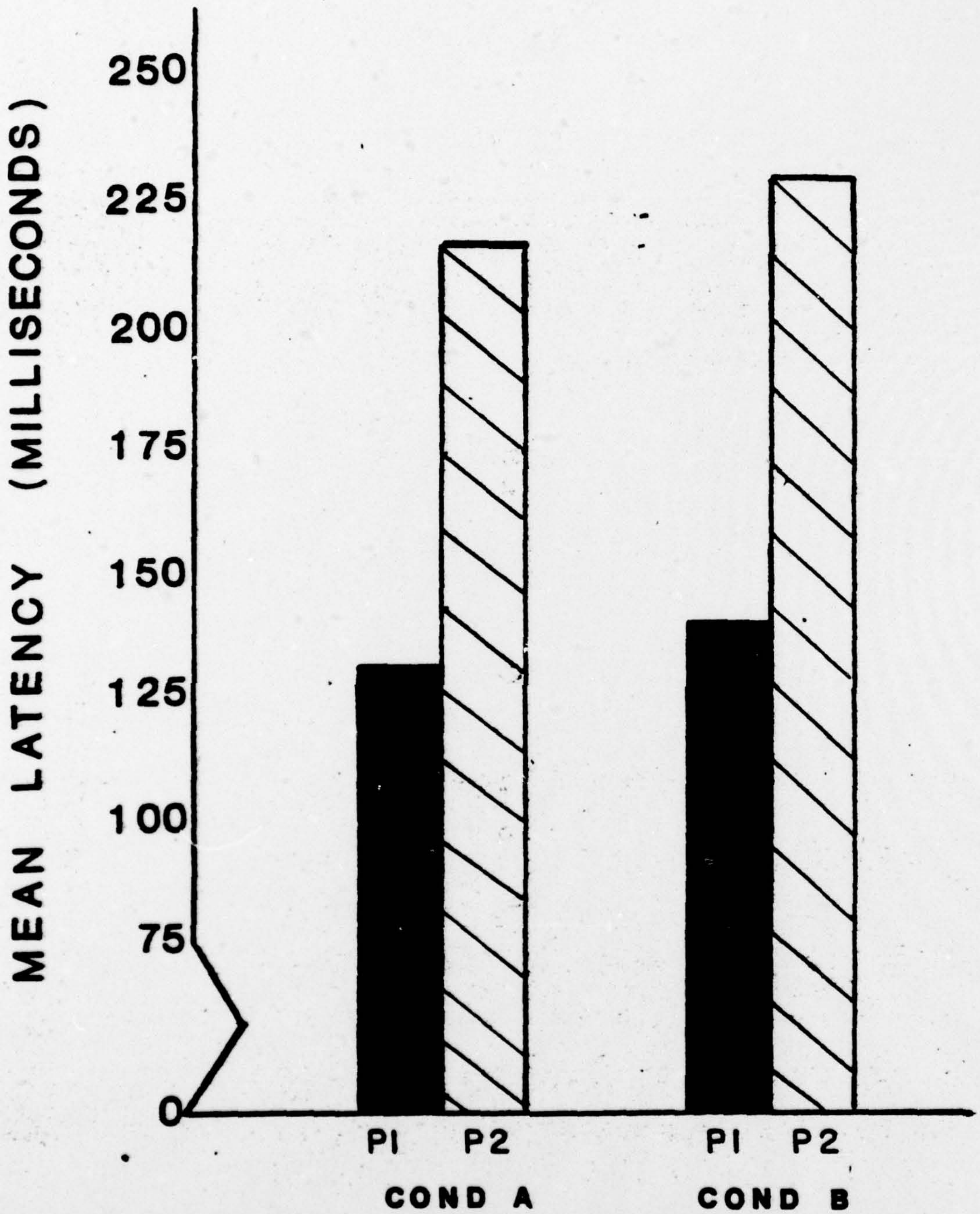

Figure 4- Mean latency for VEP components P1 and P2 under conditions A and B at O_z (10 Ss).

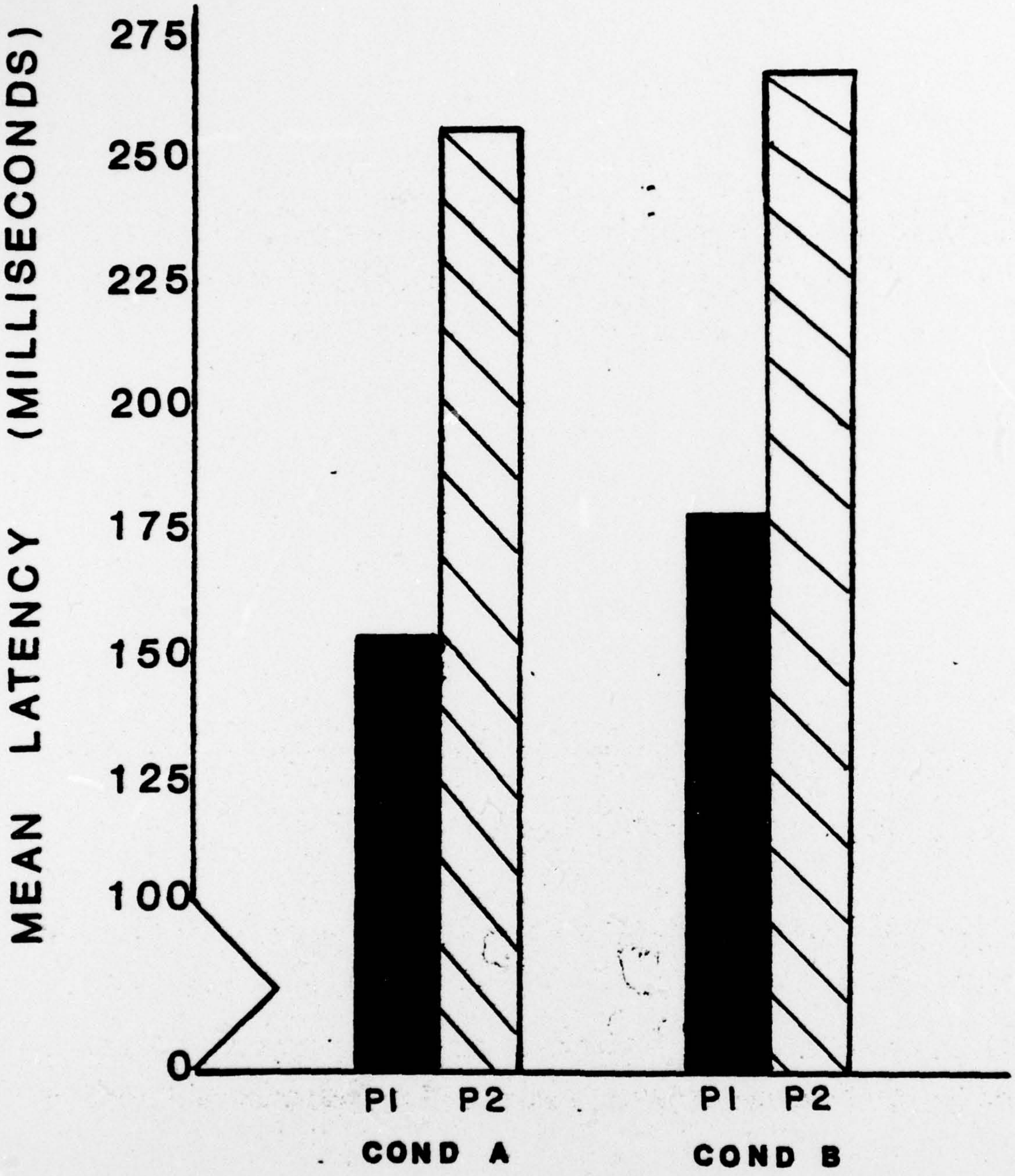

Figure 5- Mean latency for VEP components P1 and P2 under conditions A and B at C_z (10 Ss).

analysis by t-tests for correlated data (two-tailed criterion, 9 df)). The results of the t-tests for this component were: for the N2-P2 component at O_z A vs. B ($t = 5.98$, $p < .001$). This same comparison at C_z was not significant ($p > .05$). The t-test comparisons between O_z and C_z for the N2-P2 component (A vs. A, B vs. B) were not significant ($p > .05$). The latency data for both O_z and C_z did not yield significant values ($p > .05$). However, the O_z vs. C_z comparison for the P2 component did prove significant. Specifically, A vs. A ($t = 2.88$, $p < .02$) and B vs. B ($t = 3.86$, $p < .01$).

Thus the major VEP components N2-P2 showed significant VEP amplitude attenuation under Condition B (when the target was followed by a noise mask), when compared to Condition A (target presented alone). Therefore, backward perceptual masking was accompanied by VEP attenuation. Also, the P2 component of the latency data showed that there was a significant delay between O_z and C_z for the time taken to process the stimulus information (i.e., the P2 component at C_z occurred later than the P2 component at O_z).

Figure 5 shows the superimposed traces for one person (JAG) for one day at both O_z and C_z. The mean P2 amplitude for this subject at O_z for Condition A was 11.38 µV, and 6.25 µV under Condition B; at C_z for Condition A, 9.75 µV and Condition B, 5.88 µV.

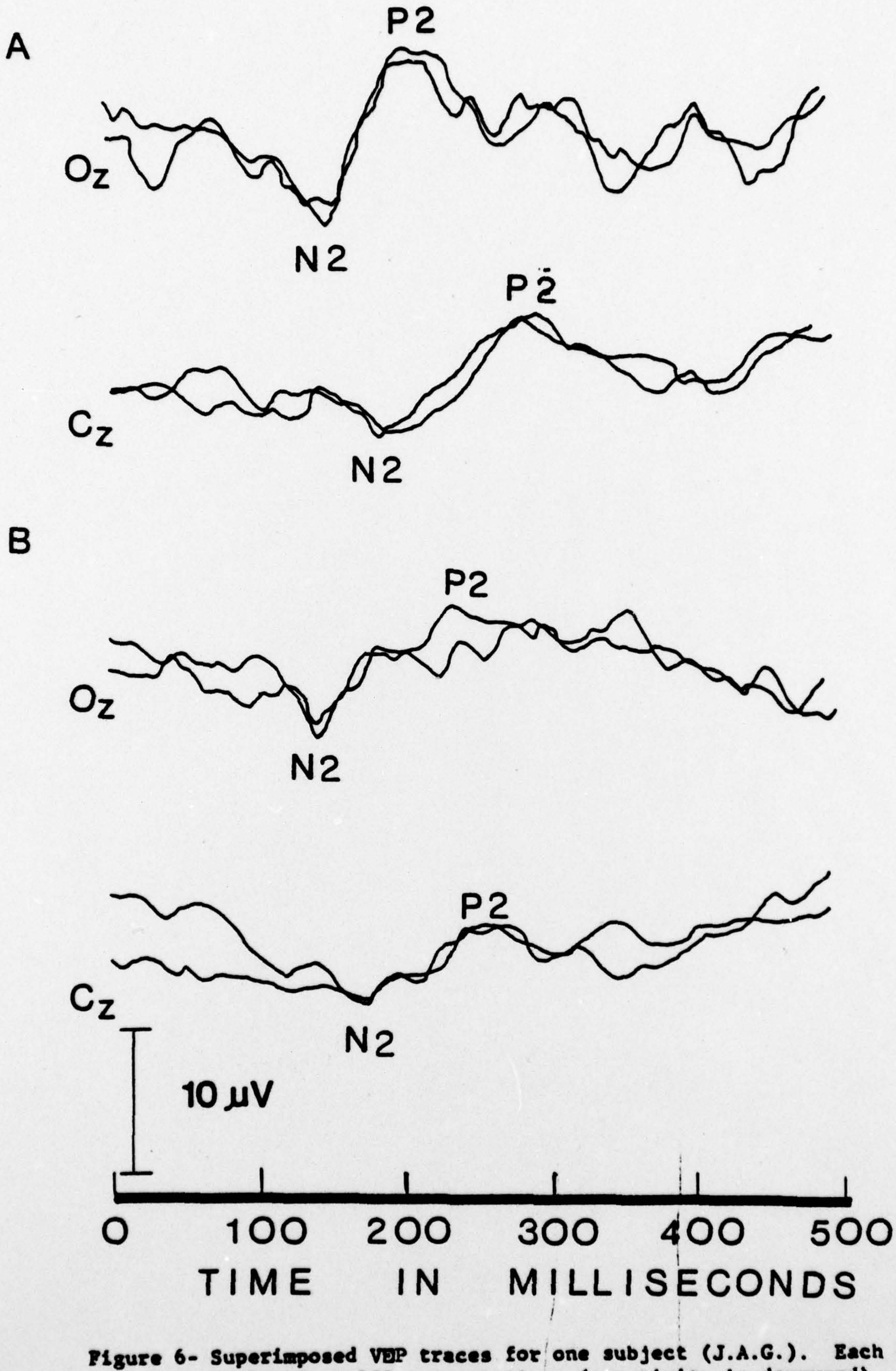

Figure 6- Superimposed VEP traces for one subject (J.A.G.). Each trace is based on 100 presentations (negativity is downward).

DISCUSSION

The results of the present experiment show that the N2-P2 (response to the target) component did occur at both O_z and C_z. Even more importantly, the results show that the response to the target under Condition B was significantly attenuated in amplitude as compared to Condition A at O_z. For Condition B at C_z the response to the target did not show a significant decrease in amplitude. These results are similar to those of Vaughan and Silverstein (1968) who reported attenuation of VEP amplitude to foveal stimulation and Andreassi et al. (1976a) who reported VEP amplitude attenuation using a backward masking paradigm. Andreassi et al. (1976b) found that the amount of VEP attenuation was related to the amount of contour interaction between target and mask, i.e., the greater the amount of contour the larger the decrease in VEP amplitude.

Possible explanatory mechanisms of the present results come from the excitatory-inhibitory action of the stimulus at the cortex. When the target stimulus was presented to the visual system it resulted in a certain amount of neural excitations (Condition A). When the target stimulus was followed by the noise mask (Condition B) adjacent as well as overlapping areas of the visual cortex were stimulated. The effect of this later coming stimulation was to reduce the amount of excitation to the target stimulus, i.e.,

inhibition was produced. This inhibitory activity is not enough to eliminate the VEP entirely but enough to significantly reduce it. In fact, the amount of VEP decrease shown here was greater than that observed in prior experiments in which other types of masking stimuli were used. For example, compare the VEP attenuation produced in the present experiment with that produced in Experiments III and IV of this report. The reason for this may be that the unpatterned mask not only bounded the target spatially, but also overlapped it at many points. The combination of bounding plus overlap probably accounted for the very effective mask characteristics demonstrated in terms of both perceptual reports and VEP amplitude decrease.

The finding that the N2-P2 component at C_z did not show significant amplitude attenuation may be explained by the fact that the primary visual projection area is located at O_z (over the occipital cortex) and that the responses at C_z are more diffuse in nature (i.e., responses to auditory, visual, and somatosensory stimuli can be recorded from this site). At the present time the authors are not aware of any other studies of visual masking and the VEP correlates of this phenomenon that have recorded the VEP from the C_z scalp location. The fact that the primary visual response is recorded at O_z and that the response at C_z is more diffuse may also explain the delay in the P2 component

at C_z for Conditions A and B. The longer P2 latency may reflect additional or later information processing of the stimuli at C_z as compared to O_z. This speculation as to the reason for the delay at C_z can only gain support by further studies of backward visual masking using scalp locations that include O_z and C_z.

In summary, the findings of the present experiment answer the research questions asked. Namely, the unpatterned mask did produce masking of the target. This was evidenced by the significant decrease in the N2-P2 component at O_z when the target was followed by the unpatterned mask. These findings were discussed in relation to an excitatory-inhibitory interaction hypothesis. The delay in P2 at C_z compared to O_z was related to the fact that O_z is the primary projection area for visual stimuli. It was speculated that delays at C_z may reflect further information processing at this central area compared to that accomplished at the primary projection site.

REFERENCES

Andreassi, J. L., De Simone, J. J. and Mellers, B. W. Amplitude changes in the visual evoked cortical potential with backward masking. Electroencephalography and Clinical Neurophysiology, 1976, 41, 387-398. (a)

Andreassi, J. L., De Simone, J. J., Gallichio, J. A. and Young, N. E. Fourth Annual Report (Baruch College, City University of New York). Contract N00014-72-A-0406-0006, December, 1976. (b)

Andreassi, J. L., Mayzner, M. S., Beyda, D. R. and Davidovics, S. Effects of induced muscle tension upon the visual evoked potential and motor potential. Psychonomic Science, 1970, 20, 245-247.

Andreassi, J. L., Stern, M. S. and Okamura, H. Visual cortical evoked potentials as a function of intensity variations in sequential blanking. Psychophysiology, 1974, 11, 336-345.

Brindley, G. S. and Lewin, W. S. The sensations produced by electrical stimulation of the visual cortex. Journal of Physiology, 1968, 196, 479-493.

Dember, W. N. and Purcell, D. G. Recovery of masked visual targets by inhibition of the masking stimulus. Science, 1967, 157, 1335-1336.

Dobelle, W. H. and Mladejovsky, M. G. Phosphenes produced by electrical stimulation of human occipital cortex and their application to the development of a prosthesis for the blind. Journal of Physiology, 1974, 243, 553-576.

Dobelle, W. H., Mladejovsky, M. G. and Girvin, J. P. Artificial vision for the blind: electrical stimulation of visual cortex offers hope for a functional prosthesis. Science, 1974, 183, 440-443.

Donchin, E. and Lindsley, D. B. Visually evoked response correlates of perceptual masking and enhancement. Electroencephalography and Clinical Neurophysiology, 1965, 19, 325-335.

Donchin, E. Wicke, J. and Lindsley, D. B. Cortical evoked potentials and perception of paired flashes. Science, 1963, 141, 1285-1286.

Fehmi, L. G., Adkins, J. W. and Lindsley, D. B. Electrophysiological correlates of visual perceptual masking in monkeys. Experimental Brain Research, 1969, 7, 299-316.

Hartline, H. K. Visual receptors and retinal interaction. Science, 1969, 164, 270-278.

Hubel, D. H. and Wiesel, T. N. Receptive fields of single neurons in the cat's striate cortex. Journal of Physiology, 1959, 148, 574-596.

Hubel, D. H. and Wiesel, T. N. Receptive fields, binocular interaction, and functional architecture in the cat's visual cortex. Journal of Physiology, 1962, 160, 106-123.

Hubel, D. H. and Wiesel, T. N. Receptive fields and functional architecture of monkey striate cortex. Journal of Physiology, 1968, 195, 215-243.

Jasper, H. H. Report of the committee on methods of clinical examination in electroencephalography. Electroencephalography and Clinical Neurophysiology, 1958, 10, 370-375.

Mayzner, M. S. The disinhibited effect in sequential blanking. Psychonomic Science, 1970, 20, 218-219.

Mayzner, M. S., Tresselt, M. E. and Helfer, M. S. A provisional model of visual information processing with sequential inputs. Psychonomic Monograph Supplements, 1967, 2, 91-108.

Robinson, D. N. Visual disinhibition with binocular and interocular presentations. Journal of the Optical Society of America, 1968, 58, 254-257.

Robinson, D. N. Disinhibition of visually masked stimuli. Science, 1966, 154, 157-158.

Ruch, T. C., Patton, H. D., Woodbury, J. W. and Towe, D. L. (Eds.), Neurophysiology, Philadelphia: Saunders, 1965.

Schiller, P. H. and Chorover, S. L. Metacontrast: Its relation to evoked potentials. Science, 1966, 153, 1398-1400.

Schiller, P. H. and Greenfield, A. Visual masking and the recovery phenomenon. Perception & Psychophysics, 1969, 6, 182-184.

Tresselt, M. E., Mayzner, M. S., Schoenberg, K. M. and Waxman, J. A study of sequential blanking and overprinting combined. Perception & Psychophysics, 1970, 8, 261-264.

Vaughan, H. G., Jr. and Silverstein, L. Metacontrast and evoked potentials. Science, 1968, 160, 207-208.

NOTE

Schwartz, M., Whittier, O. M. and Schweitzer, P. K. AERs and perception: AERs to retroactively masked stimuli do not correlate with discrimination performance (personal communication, 1977).

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This is the fifth annual report to originate from the Psychophysiology Laboratory of the Psychology Department at Baruch College. The research completed over the last 12 months has included a number of studies concered with evoked cortical potential correlates of stimulus processing in humans. The present report details the results of five separate experiments. Experiment I examines the visual evoked potential (VEP) to a target stimulus when it is perceptually masked by a second stimulus, and again when it is

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disinhibited. The disinhibition occurs when the target is clearly perceived because of the action of a third stimulus on the second. There was a significant trend toward a larger amplitude VEP to the target when it was disinhibited. More research work is needed in this area since so little information is available on the brain response to disinhibited or recovered stimuli.

In Experiment II, the effects of contiguity of target (initial) and mask (later) visual stimuli on backward masking and the VEP was examined. However, the area of the mask was varied so that it was either 68% or 97% of the target's area. Significant VEP amplitude decreases occurred when the target was followed closely in time by either of the masks.

Experiment III tested the effects of differing numbers of corner masks on perception of, and VEP to, the target stimuli. Two-corner masks (upper left and lower right) led to partial masking, but no significant VEP amplitude decrease. Four-corner masks produced more complete masking in all subjects, and a corresponding significant decrease in VEP magnitude. The two-corner mask was only 29% of the target area, while the four-corner mask occupied 57% of the area covered by target stimuli.

In Experiment IV we asked whether corner masking stimuli would be more effective than non-corner masks with respect to effects on perception and the VEP. Both corner and non-corner masks occupied less area than the target stimuli (57%). The two mask types were equally effective in producing backward masking and attenuation of the N2-P2 component of the VEP.

The fifth experiment examined the effects of a "randomly" generated noise pattern on a target. The target was a letter T and the mask overlapped and crisscrossed the T at many points along its contour. The random visual pattern proved to be a very effective mask perceptually and also led to sharp decreases in VEP amplitude. A delay was found for P2 latency at the C_z (Central) location as compared to the O_z (Occipital) area. This was related to the fact that O_z is the primary projection area for visual stimuli. The general finding of VEP attenuation with backward masking was interpreted in terms of excitatory-inhibitory interactions at the visual cortex which occur when later presented stimuli bound, or spatially overlap, earlier presented target stimuli.